The Journal of Thoracic Surgery

VOL. 12 AUGUST, 1943 No. 6

Original Communications

BRONCHOGENIC CYSTS OF THE MEDIASTINUM

WITH A REPORT OF THREE CASES

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REDUPLICATION cysts of the mediastinum of bronchial origin have been only occasionally reported. Hare[1] found no recorded example of this lesion in reviewing 600 mediastinal tumors reported before 1899. Alford,[2] in 1937, collected seven cases from the literature and reported one of his own. Other cases were reported by Money,[3] in 1937, and Johnston,[4] in 1938.

In a special monograph on the surgery of mediastinal tumors Heuer and Andrus[5] (1940) discussed the characteristics of mediastinal epithelial cysts represented by twenty-five cases reported in the literature and one personal case. Three of the twenty-five were included in Alford's report.

Six cases of this condition in adults were reported in the Cabot case records of the Massachusetts General Hospital in 1940[6] and points of particular interest will be considered later.

Some of these lesions have probably gone unrecognized, being diagnosed as other mediastinal lesions when operative exploration was not made, or called simple cysts when the microscopic section revealed no lining epithelium or other bronchial wall elements.

Bronchogenic cysts should not be confused with either dermoid cysts or teratomas of the mediastinum, both of which are of much more frequent occurrence and have been thoroughly discussed by Harrington,[7] Heuer and Andrus,[5] Hedblom,[8] and others. When sufficient tissue is examined microscopically a correct diagnosis is easily made.

From the Department of Surgery of the University of Chicago.
Received for publication Feb. 16, 1943.

Because of the infrequent occurrence of this condition as well as the diagnostic and therapeutic problems involved, three surgically treated cases are being reported.

CASE 1 (No. 282508).—E. S., a white man, 32 years of age, was admitted on April 6, 1942, complaining of dizziness and weakness of one year's duration. He had no other complaints.

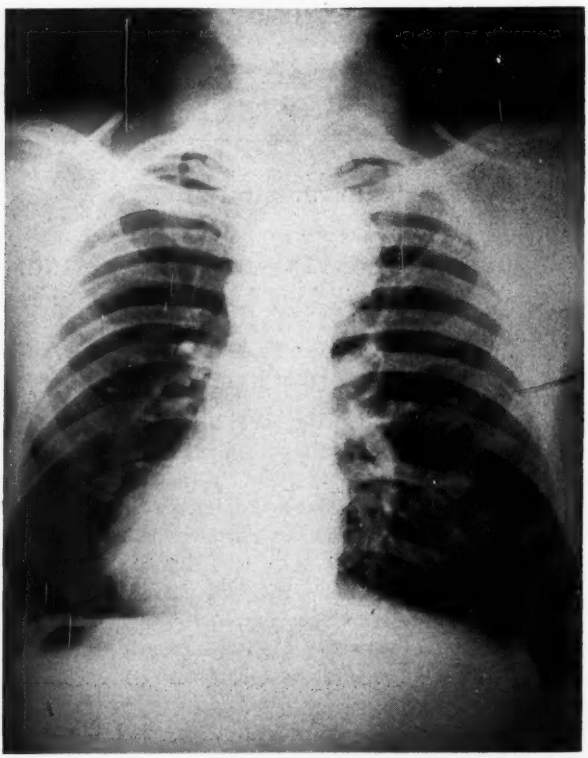


Fig. 1A (Case 1).—X-ray of chest showing an upper mediastinal opacity projecting toward the right side.

On physical examination, he appeared well developed, well nourished, and healthy. The physical findings in general were entirely normal. The blood pressure was 100/60. The heart and lungs were normal to percussion and auscultation. The abdomen and extremities revealed no abnormalities.

The blood picture, as well as the urine findings, were within normal limits. An x-ray of the chest revealed the only abnormal finding. In the superior mediastinum a round, opaque area was seen projecting to the right of the mediastinum, just above the level of the aortic arch (see Fig. 1A). On fluoroscopy this shadow was found to be located

just in front of the bodies of the vertebrae, and moved upward when the patient swallowed. This helped to differentiate the lesion from a ganglioneuroma or neurofibroma.

A small inguinal lymph node was removed for microscopic examination, but revealed no abnormal findings. On the basis of the above findings, a diagnosis of cyst or tumor of the mediastinum was made, and exploration of the mediastinum advised.

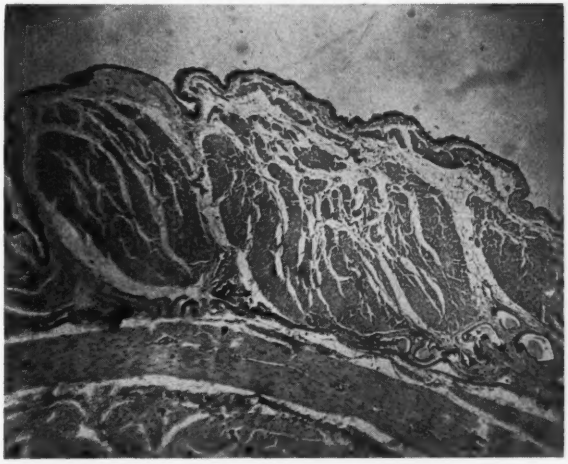


Fig. 1*B* (Case 1).—Microscopic appearance of cyst wall in an area where much smooth muscle was present; the lining epithelium is cuboidal to columnar in type.

Operation.—Operation was done April 22, 1942. Ethylene-oxygen plus ether anesthesia was administered through a face mask under slight positive pressure. The approach was through the bed of the right fifth rib after removing a long section of it. No adhesions were found between the lung and pleura. When the lung was retracted downward, a thin-walled, grayish colored cyst, measuring about two inches in diameter, was seen lying in close proximation to the trachea and esophagus, just above the arch of the aorta. After the mediastinal pleura was incised, the cyst was dissected free from the surrounding structures down to the trachealis muscle to which it was densely adherent and from which it appeared to be arising. It was removed without entering the trachea, although only a thin membrane of this structure remained. The chest wound was then closed, and the lung reexpanded by suction applied to an intercostal tube drain.

Postoperative Course.—The patient had a very smooth convalescence following the operation, the temperature being elevated for only the first two or three days and being relatively normal thereafter. The patient was discharged on the fifteenth postoperative day and has remained entirely asymptomatic.

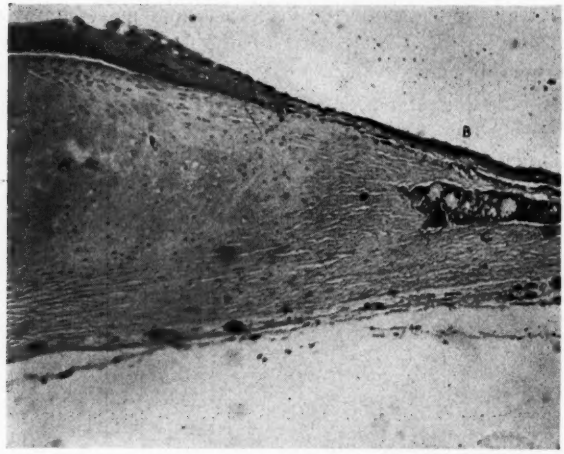


Fig. 1*C* (Case 1).—Microscopic appearance of the cyst wall: *A*, Cartilage, *B*, Columnar epithelium, *C*, Mucous glands.

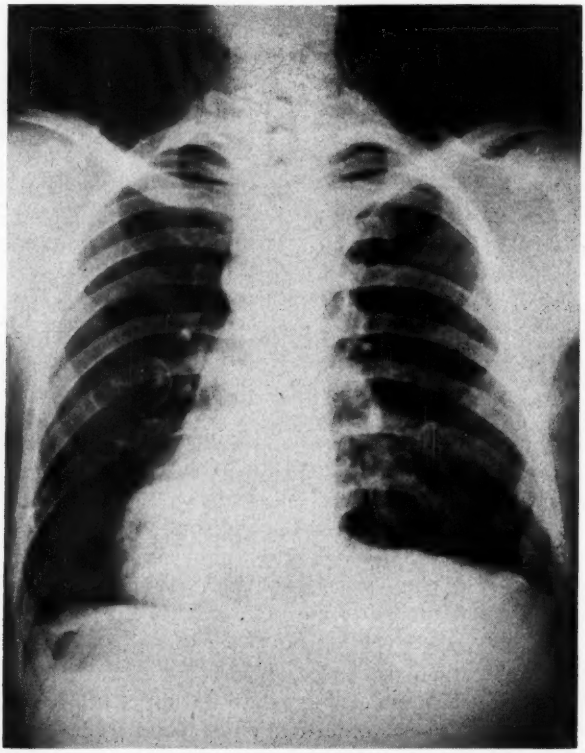


Fig. 1*D* (Case 1).—X-ray of chest taken eleven days following removal of the cyst; the fifth rib is missing.

Pathologic Anatomy.—The specimen removed was a globular cystic mass containing thin, milky-colored fluid. The wall was very thin and quite vascular. Two thickened areas appeared to contain cartilage and another appeared to be muscular (Fig. 1*B*). On microscopic examination the cyst was found to be lined by respiratory epithelium (columnar ciliated to low cuboidal in type) which, for the most part, was lying on a fibrous tissue base. In some areas there was no epithelial lining. In the above-mentioned areas, however, cartilage and considerable smooth muscle tissue were found. In other regions there were numerous mucous glands, nerves, and blood vessels (see Fig. 1*C* and *D*).

Final Diagnosis.—Bronchogenic cyst of the superior mediastinum. "Reduplication cyst of the respiratory tract."

Case 2 (No. 289461).—H. F., a white woman 39 years of age, was admitted on July 24, 1942, complaining of increasing fatigue, pain in the right side of the face, and "kidney trouble" dating back for one and one-half years. The patient was a University faculty member, and her symptoms had not kept her from doing full-time work. Her health had otherwise been good.

Physical examination revealed a well-developed, well-nourished, and healthy appearing female. Her general examination was normal. The blood pressure was 100/60. The heart and lungs were normal on percussion and auscultation. The abdomen and extremities revealed no abnormalities.

Laboratory examination revealed normal urine and blood, including Wassermann and Kahn. The sputum was normal. An x-ray of the chest revealed a sharply outlined opacity, with its convex surface projecting to the right of the heart (see Fig. 2*A*). This was thought to be either a dermoid cyst, an aneurysm, or possibly tuberculous glands. On fluoroscopic examination, this opacity showed no expansile pulsation, and was found to lie just in front of the bodies of the vertebrae and extending to the right of the heart. Because of the difficulty of explaining the patient's symptoms, and because of the inability to make a definite diagnosis, exploration of the thorax was advised.

Operation.—Operation was done on Aug. 11, 1942. Ethylene-oxygen-ether anesthesia was administered under light positive pressure through a face mask. An exploration was made through the bed of the seventh right rib after subperiosteal resection of it had been made. The pleural cavity was entirely free of adhesions. A cystic tumor was palpated on the posteromesial aspect of the right lower lung lobe which appeared to be extending out from the mediastinum. This was dissected free from the lung with some difficulty, then partially mobilized back of the heart. The cyst was opened during the dissection and found to contain a dark green viscid material having the consistency of toothpaste. After aspirating between 75 and 100 c.c. of this material, a hemostat introduced into the cyst, was found to pass for a distance of three inches through the mediastinum towards the opposite pleural cavity. The

cyst appeared to measure approximately one and one-half to two inches in its vertical dimension by three inches horizontally. It had an extremely thin wall which presented a smooth lining. About one-half of the cyst was mobilized and removed, after the lining of the remaining portion had been destroyed by swabbing with a 5 per cent solution of silver nitrate. The chest wound was then closed and the lung reexpanded by suction applied to an intercostal catheter drain.

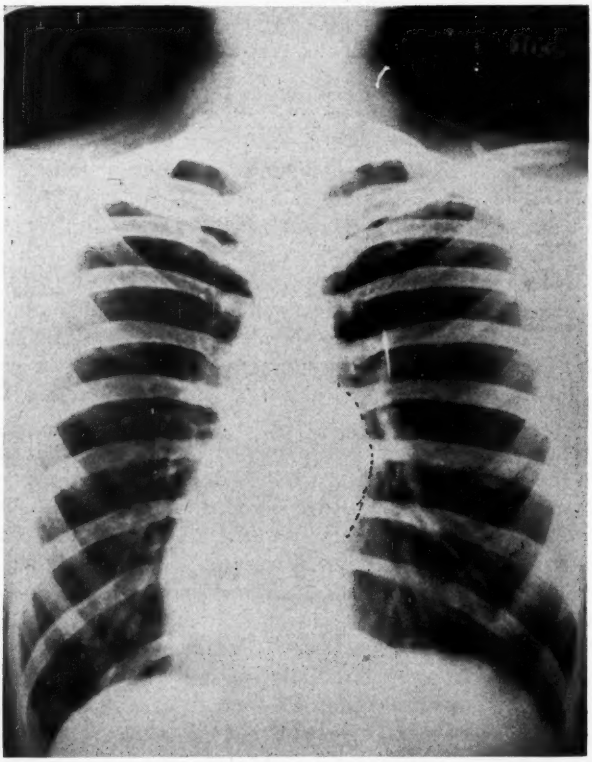
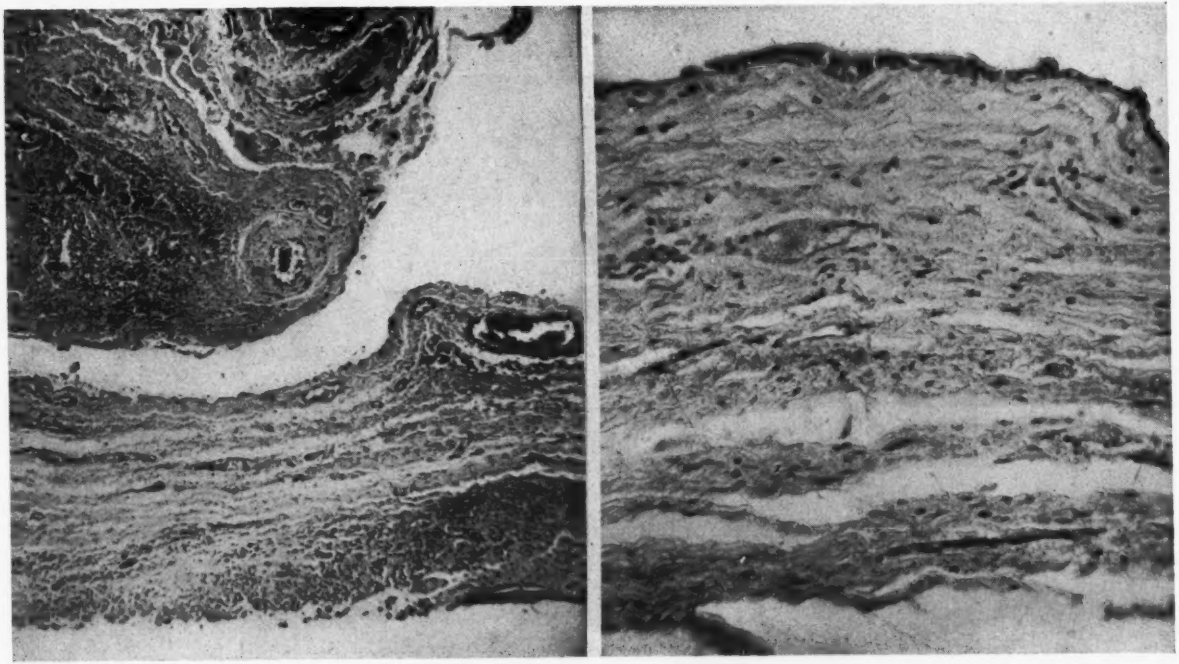


Fig. 2A (Case 2).—X-ray of the chest showing a mediastinal shadow projecting slightly toward the right side.

Postoperative Course.—The patient made a very uneventful convalescence, having practically no febrile reaction. The wound healed by primary intention, and she was discharged from the hospital on the sixteenth day following operation. She has been followed in the outpatient department or by correspondence and has had no symptoms referable to her chest since operation.

Pathologic Anatomy.—Material removed from the cyst at operation, on staining, revealed a fungus-coccidioides. Guinea pigs inoculated with the material showed a growth of a similar nature in the apex of one lung.



B. *C.*

Fig. 2 (Case 2).—*B*, Microscopic appearance of cyst wall showing fibrous tissue and blood vessels with no epithelial lining. *C*, Microscopic appearance of cyst wall at another area showing columnar ciliated epithelium.

This aspect of the case is being presented in a separate communication.[9] Microscopic sections revealed low columnar ciliated to cuboidal epithelium lying on a fibrous tissue membrane. In some regions, mucous glands were seen, and in others, considerable smooth muscle. Blood vessels and nerves were numerous (see Fig. 2, *B* and *C*).

Diagnosis.—Bronchogenic cyst of the mediastinum. "Reduplication cyst of the respiratory tract."

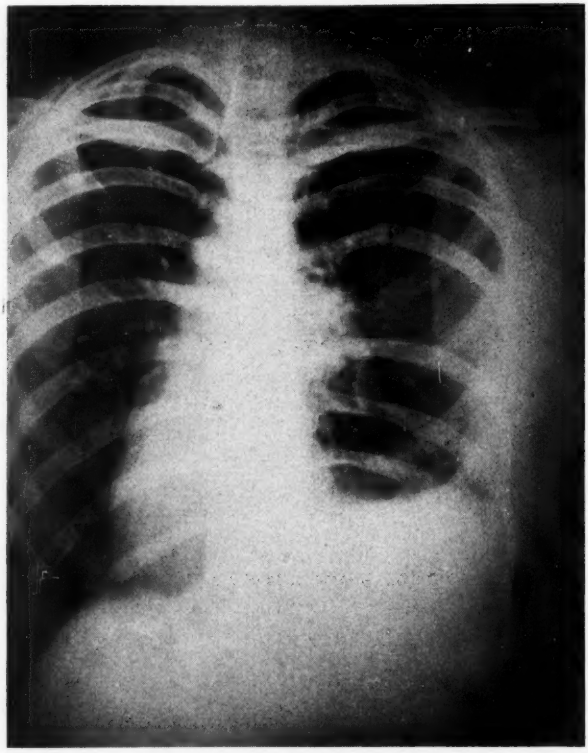


Fig. 2*D* (Case 2).—X-ray appearance of chest eleven days following partial excision of cyst; the seventh rib has been resected.

CASE 3 (No. 272554).—L. C., a white man of 54 years, was admitted complaining of chronic cough and asthma of four years' duration. The patient had an attack of "flu" four years previously and was in bed for ten days. A persistent, chronic cough, increasing in severity and accompanied by the production of very foul, yellowish sputum followed the attack of "flu." The patient reported as much as one-fourth to one-half cup of sputum per day, and the cough disturbed him especially at night, two pillows being needed for sleeping. A normal weight of 190 pounds was maintained, but due to the cough, he was constantly fatigued.

Physical examination revealed a rather obese male who coughed occasionally and had a very foul breath. The chest was hyperresonant and presented moist râles over both bases. The blood pressure was 180/98, The abdomen and extremities were normal.

The laboratory examination revealed entirely normal blood and urine findings with the exception of an occasional hyaline cast. The sputum contained no acid-fast organisms, but cultured both aerobic and anaerobic organisms including *Neisseria catarrhalis*, diphtheroid, nonhemolytic streptococci, *Streptococcus viridans*, pneumococci, and staphylococci. The B.M.R. was plus 25. An x-ray of the chest revealed relatively normal lung fields. The mediastinum, however, showed a cavity containing air and fluid, located immediately beneath the bifurcation of the trachea. This was not visible on an anteroposterior view but was recognized on an oblique film. Following a barium swallow, no communication between the cavity and the esophagus was demonstrable. Likewise, iodized oil showed no communication with the tracheobronchial tree (see Fig. 3 *A*).

Bronchoscopy.—On bronchoscopic examination, foul pus in small amounts was observed coming from the left primary bronchus. The mucosa of the trachea and bronchi appeared chronically inflamed. The carina was broadened. A localized, elevated reddened area was seen on the inferior wall of the left main bronchus about one inch below the carina. When an attempt was made to enter the left main bronchus, profuse bleeding occurred which obscured vision. The bleeding was easily controlled, but little more could be observed in the left main bronchus.

The procedure was repeated four days later with similar results.

First Operation.—Operation was performed Dec. 3, 1941. A preoperative diagnosis of mediastinal abscess communicating with the left primary bronchus was made. A two-stage drainage of this abscess was planned. Ethylene-oxygen anesthesia was administered through a face mask. An approach was made over the posterior end of the right sixth and seventh ribs through a curved incision, about four and one-half inches of the posterior ends of these ribs being removed subperiosteally including a portion of the corresponding transverse processes of the vertebrae. The parietal pleura was separated from the chest wall and vertebrae down to the mediastinum. On exposing the esophagus and region of the right primary bronchus, no inflammatory mass could be palpated, nor were there adhesions or other evidence of inflammation in this region. Two silver clips were placed as markers for identification later, on x-ray examination. This extrapleural space was now filled with about 500 Gm. of paraffin for walling off of the area through which the abscess was to be drained at a second stage. The wound was then closed in layers without drainage. Convalescence following operation was entirely uneventful.

Second Operation.—The second stage was performed eight days later, on Dec. 11, 1942, under local anesthesia. The old incision was opened and the paraffin pack removed. The uppermost of the two silver clips placed at the first operation was found to be located at the level of the cavity. Using this as a landmark, an aspirating needle was introduced into the cavity and frank pus obtained. The cavity was then opened

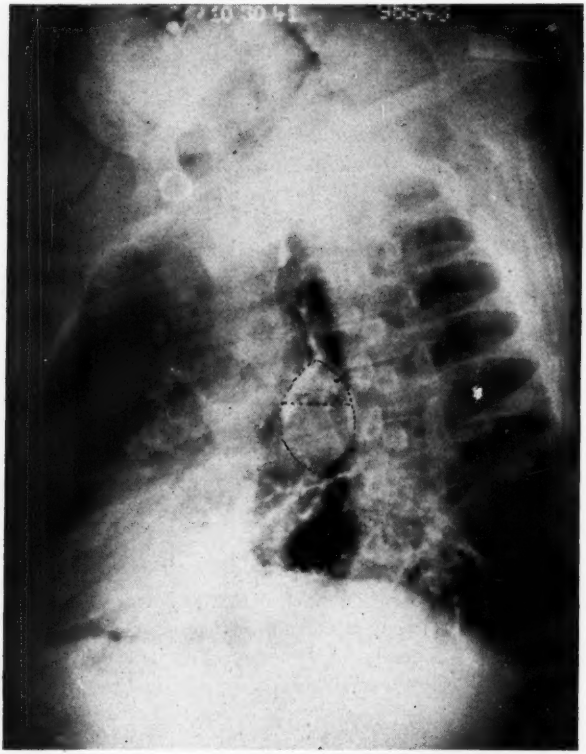


Fig. 3*A* (Case 3).—Oblique x-ray of chest showing a mediastinal shadow located beneath the carina and presenting a fluid level.

and found to measure about one and one-half inches in diameter. The wall could easily be dissected away from the surrounding structures thus suggesting at once that it was an infected cyst instead of an abscess. A portion of the wall was removed for microscopic examination and a hard rubber tube about 1.5 cm. in diameter was sutured in place and brought out to the skin edge. A plain gauze pack was placed in the wound about the tube. No closure was made. Convalescence following this second stage was again uneventful with the exception of a febrile reaction to sulfathiazole therapy. The patient was discharged from the

hospital with the drainage tube in place on the nineteenth day following operation.

Pathologic Anatomy.—Microscopic sections of the cyst wall revealed a lining of stratified squamous epithelium overlying an organizing, inflamed granulation tissue bed rich in capillaries. Beneath this were smooth muscle and mucous glands. In some areas, columnar ciliated epithelium was seen (see Fig. 3 *B*).

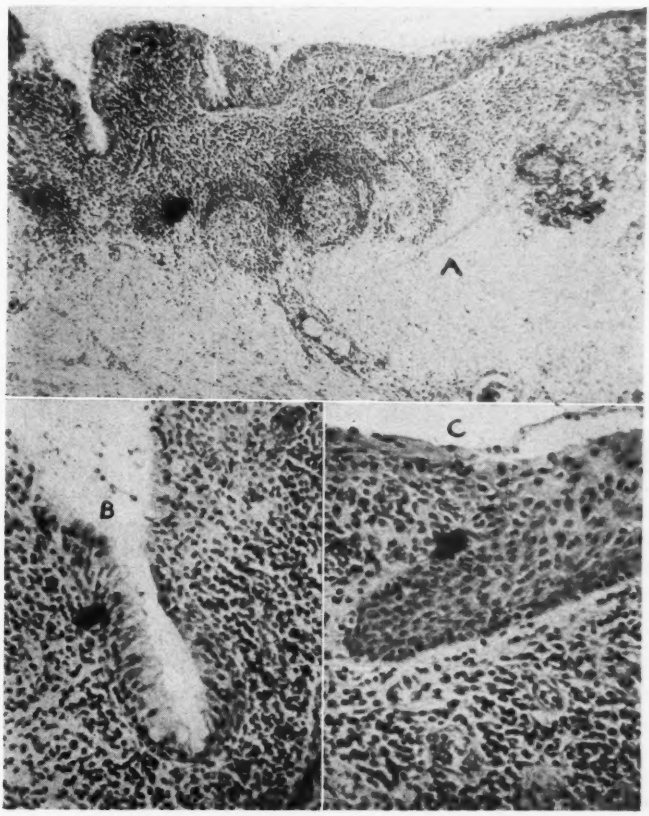


Fig. 3*B* (Case 3).—Microscopic appearance of cyst wall: *A*, Low power showing stratified squamous epithelium and in one place columnar ciliated epithelium lying on granulation tissue; two lymph follicles and blood vessels are seen. *B*, High power of columnar epithelium. *C*, High power of stratified squamous epithelium.

The patient's wound continued to drain a small amount of purulent material. Almost immediately following operation the cough was relieved and did not recur. The patient was followed in the outpatient clinic. X-rays made on Feb. 6, 1942, following the introduction of iodized oil in the cavity through the drainage tube, revealed little or no diminution in the size of the cavity (see Fig. 3 *C*).

Third Operation.—The last operation was on Feb. 17, 1942. The patient was readmitted for removal of the cyst under ethylene-oxygen-ether anesthesia. Through an oblique incision over the right sixth rib, almost the entire length of this rib was removed subperiosteally, and the pleural cavity entered. A small segment of the fifth rib was also removed to obtain adequate exposure. After the lung was partially freed from the pleura posteriorly, the cyst wall was exposed, and by a combination of blunt and sharp dissection, it was partially mobilized from the esophagus posteriorly and the pericardium anteriorly. It was quite

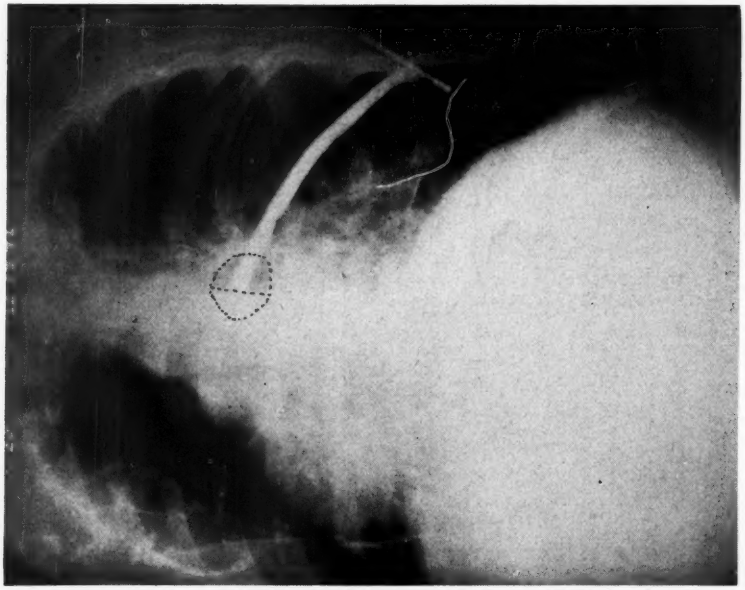


Fig. 3*C* (Case 3).—X-ray of chest with patient lying on the left side following introduction of iodized oil through the drainage tube into the mediastinal cyst; note size of cyst with oil level.

firmly attached to the latter structure and it was thought to be too hazardous to complete the mobilization. Only about four-fifths of the cyst wall was removed. The lining of the part remaining was thoroughly cauterized with a 35 per cent solution of silver nitrate to destroy the epithelium. A female retention catheter was brought out through the old drainage tract leaving the phalanxed end of the catheter in the region of the partially resected cyst. The pleural cavity was then drained by a pezzar catheter brought out through a stab wound in the fourth interspace anterolaterally. The chest wall was closed in layers, the lung being reinflated by suction applied to the catheter. A vaseline gauze was placed about the female catheter to maintain an airtight connection.

Postoperative Course.—Following the third stage, except for the development of a small, encapsulated empyema, convalescence was uneventful.. The patient was discharged from the hospital twenty-eight days following surgery. Follow-up correspondence six months later found the patient in good health and with no recurrence of his preoperative symptoms. His wounds were completely healed.

DISCUSSION

The mode of development of this anomaly is unknown but is probably similar to that of congenital cysts within the lung. Most of the cyst located in the mediastinum, although in close proximity to the major bronchi or trachea, unlike most intrapulmonary cysts have no connection with the air passages. In this regard, an interesting report by Chiari[10] presents five cases of diverticular of the trachea. All were located on the right side just above the carina. It is conceivable that such a projection might be pinched off during the stage of development, giving rise to the formation of a cyst similar to that in Case 1 of this report.

Grossly the cysts are very thin-walled and are filled with a thin, milky-colored mucoid material containing a desquamated epithelium which is under considerable pressure. They project more often toward the right side. The lining is smooth and consists of flattened to columnar ciliated epithelium. In some places there is no epithelium, as in two of five Massachusetts General Hospital cases and in Money's case, the epithelium probably having atrophied due to pressure, or being lost during the preparation of the microscopic sections. The remainder of the cyst wall consists of fibrous tissue, smooth muscle, mucous glands, cartilage, nerves, and blood vessels.

The clinical course depends chiefly upon the size and location of the cyst and whether symptoms are produced by pressure on adjacent structures such as the air passages, esophagus, or blood vessels. Many cysts produce no symptoms and are found accidentally on x-ray or fluoroscopic examination of the chest. Thirteen of twenty-five cases collected by Heuer and Andrus were first discovered at autopsy, and in two of our three patients the cysts were producing no symptoms.

Pressure on the trachea or large bronchi may be sufficient to produce symptoms of anoxia (Alford, Money, and Johnston), or may lead to a chronic infection of the respiratory passages (Cabot, Heuer and Andrus).

Occasionally the cyst may become infected, as in Case 3 of this report, and give rise to symptoms of pulmonary suppuration.

The diagnosis is usually difficult but is aided by x-ray and fluoroscopic examination. Its location in the region of the trachea or major bronchi with vertical movement on swallowing tends to differentiate it from a dermoid cyst or a tumor of nervous tissue origin. An aneurysm is usually excluded by the lack of pulsation on fluoroscopic examination. Bronchoscopic examination is indicated in cases where infection is

present or where pressure on the air passages produces symptoms. X-rays of the chest following a barium swallow or iodized oil filling of the bronchial tree may be helpful in some instances.

Because of the rarity of this lesion and the difficulty of differentiating it from other mediastinal lesions, exploration is indicated. Although some cysts never produce symptoms, the likelihood of its increasing in size and compressing adjacent structures or becoming infected make surgical excision the procedure of choice. Drainage of the cyst is to be avoided (unless originally infected) since a persistent sinus is apt to result. In some cases the location of the cyst makes complete excision hazardous. Partial excision with destruction of the lining mucosa of the part remaining has given good results in two of our three cases. Where the cyst is already infected a two-stage drainage with subsequent excision of the cyst may be made.

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DECOMPRESSION OF THE HEART IN SEVERE SCOLIOSIS

Report of a Case

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SURGICAL decompression of the heart has been carried out for several fundamentally different pathologic conditions of the chest. In some of these, the lesion is in the heart or its enveloping pericardium; in others, including the abnormality described in this communication, there is deformity of the thoracic cage which causes compression of an otherwise normal heart.

In the first category might be placed cardiac tamponade from hemopericardium which may require surgical measures for its relief. Another lesion which has been found to be remarkably amenable to operative treatment is chronic constrictive pericarditis. The operation consists of the removal of the anterior portion of the thickened and adherant pericardium. Heuer and Stewart[1] collected 150 cases which had had this type of pericardiectomy, of which 53 patients were said to be cured and 28 improved. In their own series of 7 cases, these authors had no operative mortality; 3 patients were well and 3 improved. This procedure should be distinguished from the operation of cardiolysis for chronic mediastinopericarditis suggested by Brauer,[2] in 1902. Here, none of the pericardium was removed, but by removing the overlying osseous and cartilaginous structures, the heart was given a soft instead of a rigid structure to pull against. Hence, this was an untethering procedure rather than a decompression, a fact which is well illustrated by descriptions in two of the early operative reports,[3, 4] in which it was said that the heart fell away from the chest wall when the portions of ribs were removed subperiosteally.

It has been suggested that in certain instances, the beneficial effects of the Brauer cardiolysis might be due to the release of pressure on a markedly hypertrophied heart. Accordingly, several operations have been carried out with such an end in view. E. A. Graham[5] reported two cases, in 1929. Both of his young patients made operative recoveries and were symptomatically improved, but unfortunately both died within five months, one of heart disease and the other of pneumonia. The late Laurence O'Shaughnessy[6] performed a similar operation on one patient and was pleased with the result. Very recently, Newton and Levine[7] gave a final report on a patient who had had surgical measures carried out on account of marked cardiac enlargement associated with

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Received for publication Feb. 17, 1943.

dysphagia. Partial resection of the third, fourth, and fifth ribs on the left had been carried out with improvement in the symptoms of dysphagia and palpitation. Her condition was followed for nine years, until she died in her sleep, presumably of heart disease.

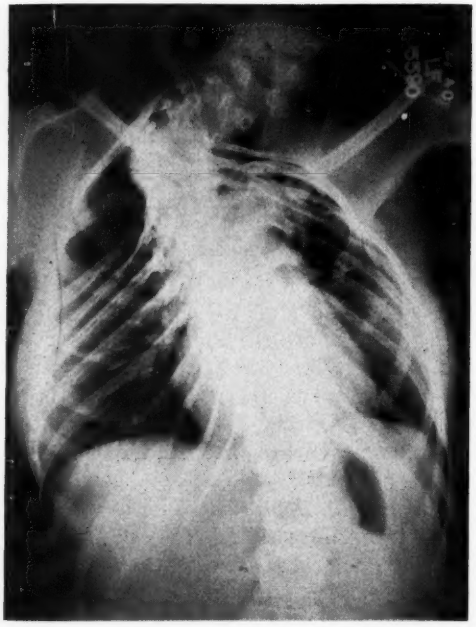

Fig. 1.—Anteroposterior roentgenogram showing marked scoliosis.

In the second category are the deformities of the chest which may cause harmful pressure on the heart. The most important one is the condition known as funnel chest, pectus excavatum, trichterbrust, or chonechondrosternon. In this abnormality, the marked depression of the sternum reduces the anteroposterior dimension of the lower mediastinum until the heart is either pressed upon severely or displaced to the left, possibly with torsion. Ochsner and DeBakey[8] reviewed the literature thoroughly and found 32 cases in which operation had been done. They classified the various surgical procedures as follows: (1) Chondrosternal resection, (2) T sternotomy and (3) sternal mobilization. The last named had no associated mortality and gave the best results in the opinion of these reviewers. Brown[9] recently reported his operative experience in 5 cases of funnel chest. Excision of a portion of the sternum and adjacent costal cartilages had been carried out in one case, and sternal mobilization in another, while three infants had been subjected to the comparatively minor procedure of sectioning the substernal ligament and the sternal attachments of the diaphragm.

We have not encountered a report of surgical intervention for cardiac compression due to severe scoliotic deformity. Two years ago, we had the opportunity to examine and operate upon a patient in such a case, the details of which are presented in this communication.

CASE REPORT

H. W. (No. 305590), a white woman, 24 years old, was referred to R. H. Durham of the Division of General Medicine with the complaints of chronic fatigue and curvature of the spine. She stated that she had been more or less tired for about ten years, but there had been distinctly more fatigue for two years. She was employed as a comptometer operator, having worked at this position for three years, but she found it very difficult to work a full day. She became dyspneic when she climbed one flight of stairs; palpitation occurred with the slightest exertion. There was occasional swelling of the ankles.

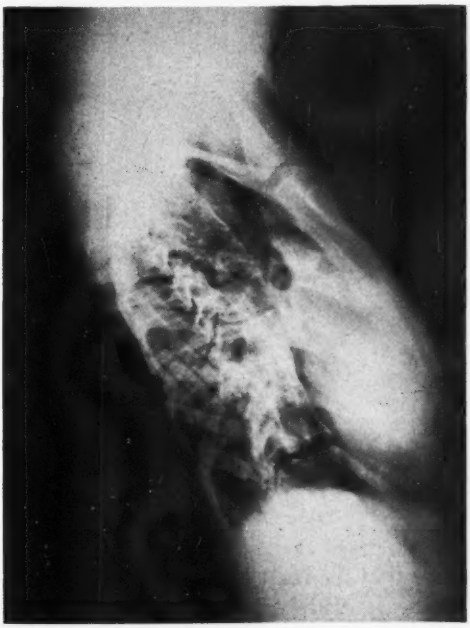

Fig. 2.—Lateral roentgenogram showing cardiac shadow occupying narrow space between the sternum and vertebral column.

The scoliosis had been noted when she was 3 years old. It progressed rapidly and was easily noticeable by the time she was 10 years of age. In the course of a physical examination in high school, she was told that she had "heart trouble." Because of this, her physician had curtailed her activity and had prescribed a diet, a tonic, and general supportive measures.

On Feb. 26, 1940, the patient was admitted to the hospital for study. Routine physical examination and certain special studies were carried out. She was 4 feet 11 inches tall, and weighed 84 pounds. Temperature was normal; the

Fig. 3.—Operative exposure of pericardium; the heart tends to bulge out around the exploring finger.

pulse varied from 80 to 120 per minute, but was usually about 100. Blood pressure was 120/80 on several occasions. There was marked scoliosis with convexity to the right in the middle and upper thoracic region with winging of the right scapula. It was stated that "the left side of the chest heaves with each heartbeat." Auscultation revealed a loud, harsh systolic murmur in the pulmonic area. Cardiac dullness was 10 cm. to the left and 3 cm. to the right of the middle of the sternum. The rest of the physical examination showed nothing of note.

The electrocardiogram was interpreted as indicating only sinus tachycardia. Venous pressure in the right arm was 11 cm., in the left, 14 cm. on one occasion. Vital capacity was 1300 c.c. Roentgen examination of the chest demonstrated the marked scoliotic deformity (Figs. 1 and 2). The lateral view was especially interesting, since it showed the

very small space between the sternum and vertebral column; it appeared that the heart was being pinched between these two bony structures. This appearance was consistent with the clinical observation of marked heaving of the anterior chest wall with each beat of the heart.

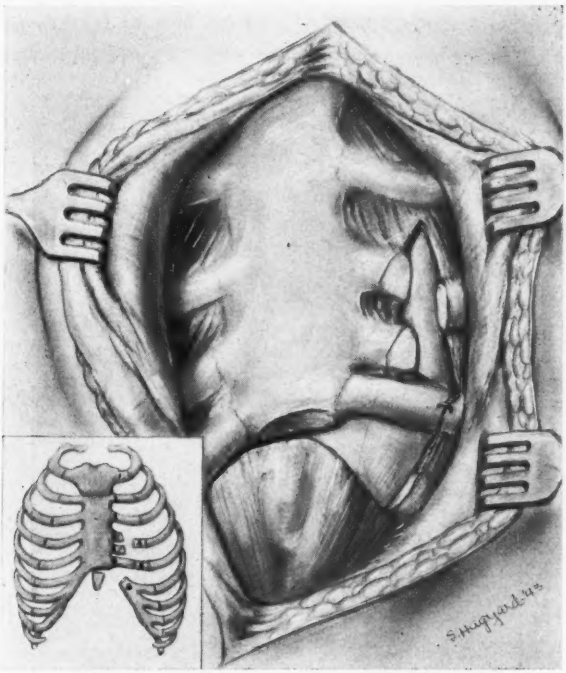

Fig. 4.—Showing the manner of rotation and fixation of the sternum to remove pressure from the heart.

It was decided that some or all of the patient's cardiac symptoms might be due to mechanical compression of the heart, and surgical intervention was tentatively advised. She was observed for seven months, at the end of which time she presented herself for operation, stating that her symptoms had increased to the point where she could no longer carry on her work. Since there was no precedent for a procedure on this type of case, the reports in the literature on the treatment of funnel chest were carefully studied. An operation similar to that recommended by Ochsner and DeBakey[8] was planned. In this procedure, the sternum is mobilized by cutting through the cartilages of the ribs on both sides, after which it is drawn anteriorly and held in the corrected position by a Parham band which passes around it and is fastened to a metal frame incorporated in a plaster body jacket. Accordingly, several days before operation, a bivalved body cast was prepared for our patient, so that it would be ready for use postoperatively.

Operation was carried out on Oct. 9, 1940 (R. D. McC. and C. R. L.). Anesthesia was obtained by inhalation, ethylene, and a small amount of ether being used. Positive pressure administration with the face mask was planned if pneumothorax should occur. A curved incision with the convexity toward the right began in the region of the left costal margin and extended to the middle of the sternum at the level of the third rib. The incision was deepened until the ribs and sternum were

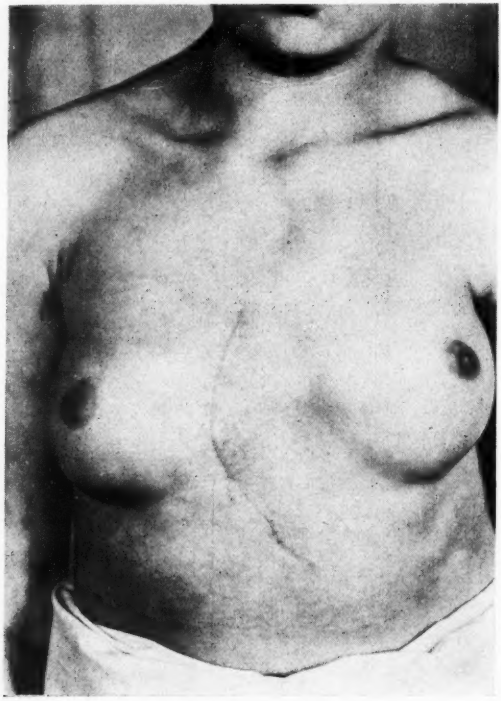

Fig. 5.—Healed operative scar.

encountered. The pectoral fascia and muscular origins of both pectoral muscles were reflected laterally to expose the lower two-thirds of the sternum and the adjacent cartilages. Two of the lower costal cartilages on the left were divided, as were the intervening intercostal structures. At this point, a finger was introduced between the sternum and the pericardium and it was noted that the heart exerted considerable pressure on the exploring finger (Fig. 3). The remaining costal cartilages on the left, up to and including the third, were cut and the xiphoid process was separated from the sternum. This procedure mobilized the sternum to such an extent that it could be elevated to relieve all pressure on the heart.

The original plan was to support the sternum in the corrected position by means of skeletal traction attached to a body cast. However, manipulation of the sternum showed that a much better method for maintaining the new position was available. On account of the resiliency of the structures of the anterior thoracic wall, the sternum could be rotated slightly in a counterclockwise direction, so that the lowest stump of cartilage on the sternal side could be caused to impinge against the lateral stump of the next highest rib (Fig. 4). Since the lowest cartilage stump was forced into a relatively short gap, the sternum and adjacent structures were forced to bow anteriorly and the sternum was held away from the heart. The chondral stumps were reciprocally

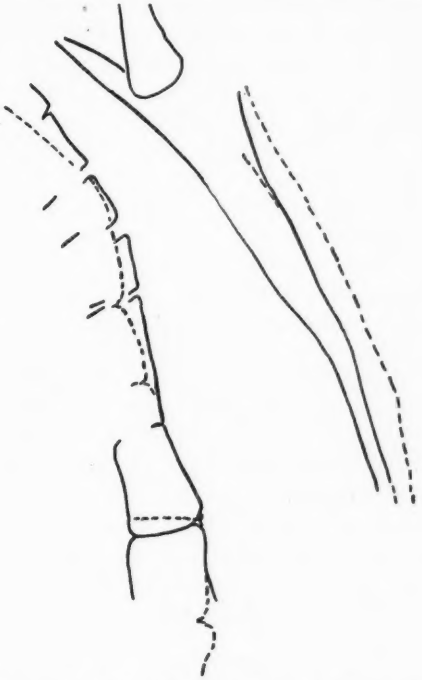

Fig. 6.—Pre- and postoperative lateral roentgenograms superimposed. (Dotted lines, postoperative.)

notched with a knife to prevent slipping and approximation was maintained by placing a silver wire through drill holes. The remaining cartilage stumps were trimmed away as necessary to make the anterior thoracic framework smooth, after which the pectoral muscles were allowed to fall back in place and were sutured. The skin was closed with interrupted silk sutures.

The operation lasted one hour and twenty minutes. The pulse was 120 at the beginning of induction of anesthesia; it fell to 80 when surgi-

cal anesthesia was reached, and remained at 70 to 80 throughout the procedure. Blood pressure was constant at 130/70.

The postoperative course was satisfactory; the wound healed per primam (Fig. 5). There was considerable tachycardia for the first ten days, with rates varying from 120 to 130. Thereafter, until the patient was discharged on the fourteenth postoperative day, the pulse did not exceed 90 per minute. The chief objective finding before operation had been the roentgen appearance of compression of the heart, revealed in the lateral exposure. Therefore, postoperative x-rays were made, the utmost care being taken to use identical exposure technique with regard to distance, etc. Tracings of the vertebral column and sternum in the films made before and after the operation have been superimposed in Fig. 6, and these show an apparent outward displacement of the sternum.

Since the patient's presenting symptoms had been chiefly subjective, an attempt was made to obtain a true assessment of any change in these symptoms during the outpatient follow-up. The following progress notes, made by several observors, indicate consistently that the patient was satisfied with the operation.

Nov. 15, 1940, ". . . Since she was previously seen here she has had no more pain in the chest. She is less conscious of her heart action." Jan. 18, 1941, "Feeling much better. Present weight is the highest she has ever attained. No dyspnea unless she walks quickly. . . ." April 19, 1942, "She is feeling considerably better and her breathing is much less labored than it was when we last saw her. She does not get as fatigued as she did and is able to carry on a very difficult occupation as anyone else would." Sept. 27, 1942, "Normal activity is accompanied by no symptoms of cardiac origin." Oct. 31, 1942, "She has been working hard and getting along quite nicely." Letter from patient, Jan. 30, 1943, "I am feeling fine."

The above progress notes are in sharp contrast to those recorded during the seven months of observation preceding the operation, the last of which states "Returns with increasing fatigue. She is ready for any operative procedure deemed advisable."

SUMMARY

A patient with cardiac symptoms presumed to be due to incarceration of the heart from severe scoliotic deformity was operated on with gratifying results. This is apparently the first operation of its kind to be recorded in the surgical literature.

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SURGICAL ANATOMY OF THE BRONCHI AND VESSELS

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THIS report is part of an extensive study of both the normal and abnormal anatomy of the hilus. Although this must remain incomplete for the duration, it may be useful to illustrate graphically some of the more or less normal surgical anatomy of this area which has been somewhat neglected.

Trachea and Bronchi (Photos 1 and 2, Fig. 1).—The trachea extends from the sixth or seventh cervical vertebra to its bifurcation at the fourth or fifth dorsal vertebra which corresponds to the second and third costal cartilages. It lies directly anterior to the esophagus which swings slightly to the right side at and below the bifurcation to contact the right lung (Photo 2). The aorta arches over the left main bronchus at this level and descends lateral to the esophagus. The right main bronchus, deviating only 25 degrees, is practically a continuation of the trachea. It is short since the branch to the upper lobe arises from its superolateral surface just below the level of the main carina. From the anteromedial aspect of the continuing stem bronchus the middle lobe bronchus originates slightly lower. This courses in an anterolateral curve over the lower lobe bronchus, a continuation of the right stem bronchus, until it divides into the ventral, dorsal, and lateral branches. The left main bronchus joining the trachea at an acute angle of roughly 75 degrees is about 5 cm. in length, at least twice that of the right side. After the upper lobe bronchus arises from its lateral and superior wall it angulates slightly toward the midline as the lower lobe bronchus. The blood supply of the lungs fits well into this basic bronchial structure.

Bronchial Arteries.—The bronchial arteries usually arise from the first portion of the thoracic aorta but, particularly on the right side, may originate from the third or fourth intercostal artery. They reach by a short direct course the posterior wall of the bronchi which they follow closely.

Pulmonary Artery.—The pulmonary artery runs from the right ventricle along the left side of the ascending aorta to its arch where it divides into right and left branches (Photos 3 and 4, Figs. 2 and 3).

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Received for publication Sept. 11, 1942.

The right pulmonary artery bends sharply under the aorta and vena cava to emerge on the surface of the right main bronchus (Photo 5). The left pulmonary artery continues the direction of the main pulmonary artery along the left and inferior aspect of the aorta with which it arches over the left main bronchus. At the mid-portion of the arc and just superior to the left main bronchus the ligamentum arteriosum connects them (Photos 9 and 10, Figs. 2 and 3).

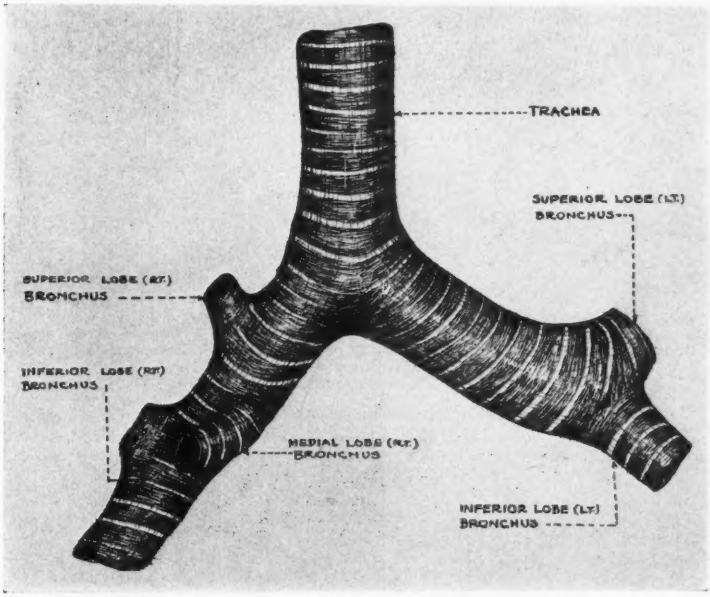


Fig. 1.—Trachea and bronchi.

The right pulmonary artery, after passing behind the aorta and vena cava to the anterior surface of the right main bronchus, divides into two parts. Usually at the origin of its bronchus the supply to the upper lobe comes from a major branch of the right pulmonary artery (Photos 6 to 8, Figs. 3 and 4). This division may occur as far medially as the posterior aspect of the vena cava. The continuing branch of the right pulmonary artery descends on the anterolateral face of the stem bronchus. It is lateral to the middle lobe bronchus which courses over the artery (Photos 6 and 7, Figs. 3 and 4). Although the upper lobe receives most of its blood supply from the first branch, it commonly has a medium-sized branch from the descending portion of the right pulmonary artery (Photo 6). The middle lobe is supplied by the descending portion of the pulmonary artery through two or three branches, which enter the lobe lateral and somewhat posterior to its bronchus

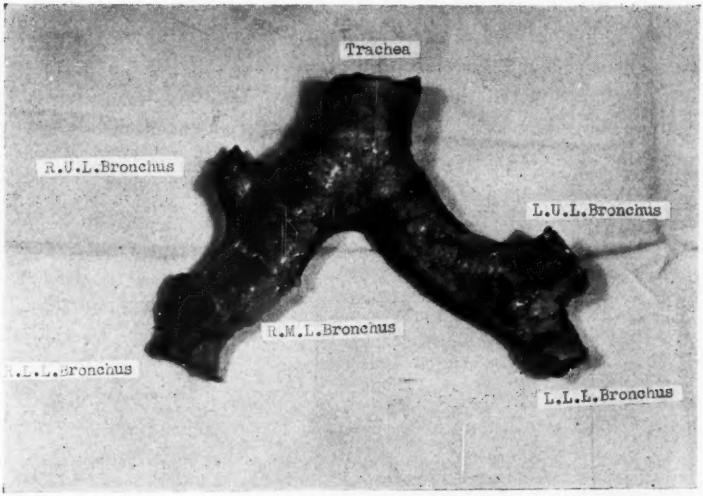


Photo 1.—Anteroposterior view of lower trachea and bronchi. Note the small angle of deviation on the right, the large angle on the left and the position of right middle lobe bronchus coursing over the stem bronchus. This photograph is reproduced in Fig. 1.

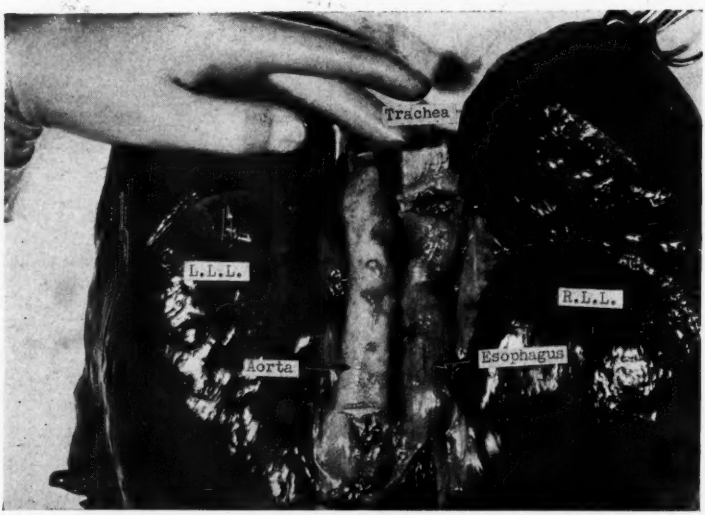


Photo 2.—Posterior view showing the relative position of the aorta, esophagus, and trachea. Note the approach of the esophagus to the right lower lobe in the lower limit of the photograph.

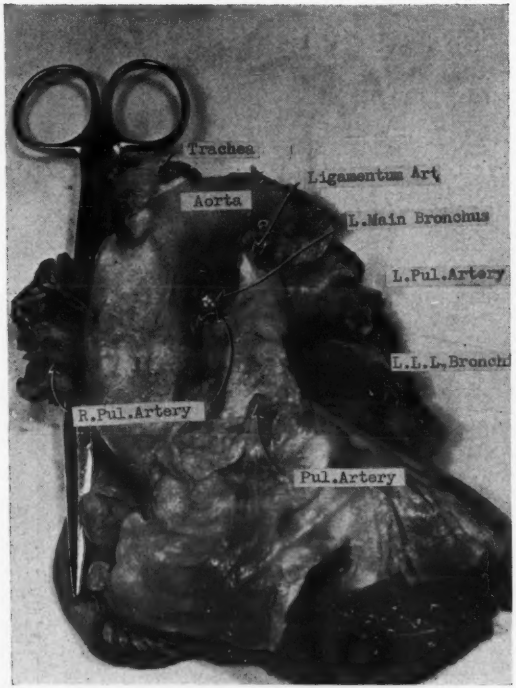


Photo 3.

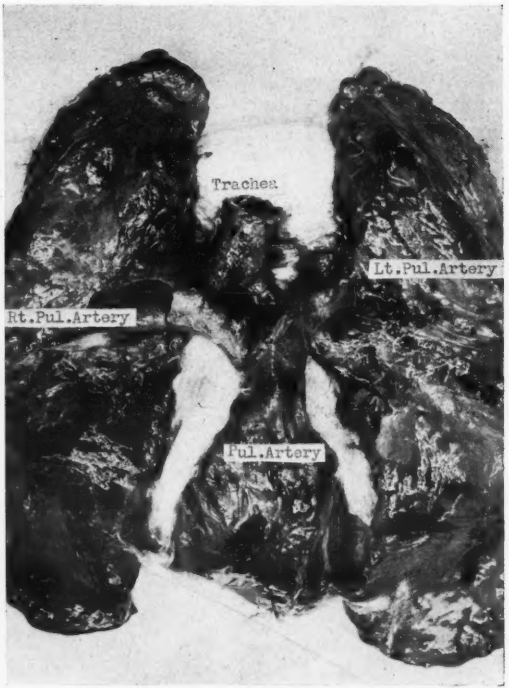


Photo 4.

Photo 3.—Anteroposterior view of aorta and pulmonary artery from the left side. Most of the heart has been removed.

Photo 4.—Anteroposterior view of a portion of the heart with the pulmonary artery and its branches dissected to the bronchi. All other vessels and portions of the heart have been removed. This photograph is reproduced in Fig. 3 with superposition of the pulmonary artery on Fig. 1.

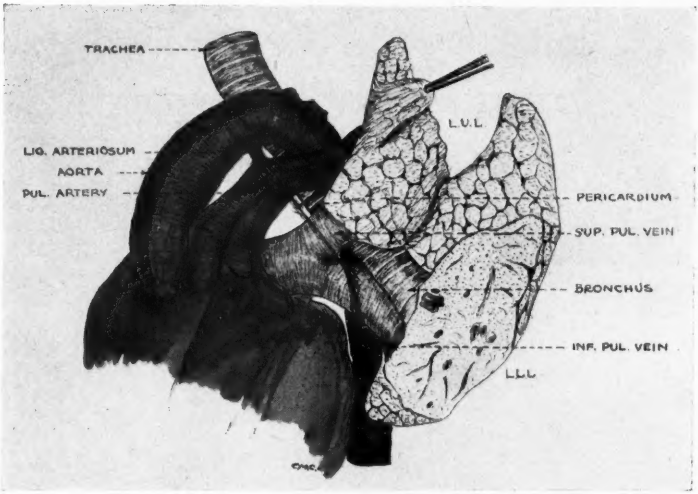


Fig. 2.—Left lateral anterior view.

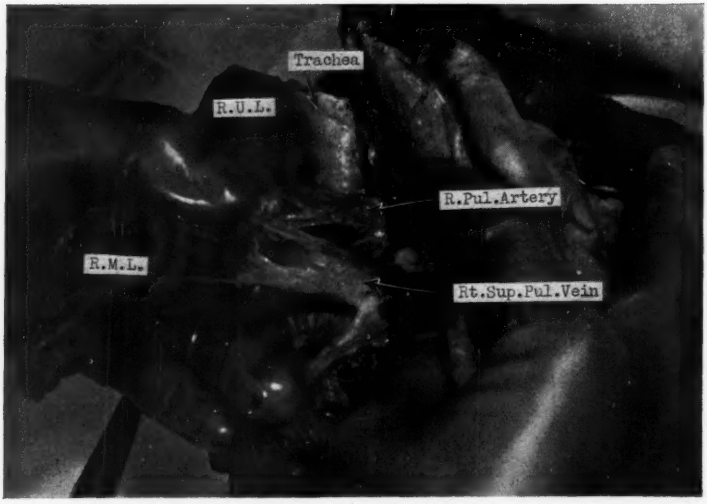


Photo 5.—Right anterior view of the right pulmonary artery and superior pulmonary vein. Note how the vein covers the lower division of the artery. The superior pulmonary vein is sending a small branch into the right lower lobe. The vena cava has been retracted medially by the index finger. The lungs have been partially removed.

(Photos 6 and 7, Figs. 3 and 4). The terminal branches of the descending artery supply the lower lobe (Photos 6 and 7, Figs. 3 and 4). In its course, the right pulmonary artery runs directly under the superior pulmonary vein (Photos 6 to 8). In the surgical dissection of the hilus on the right side it must be remembered that the pulmonary artery may be almost completely covered if the superior pulmonary vein divides in a lateral position (Photo 4).

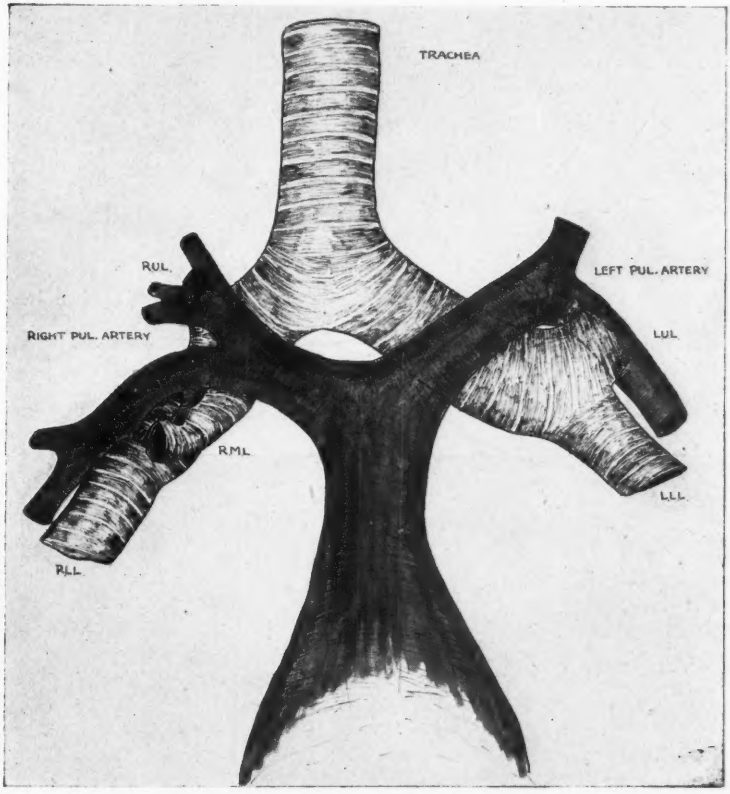


Fig. 3.—Anterior view.

The left pulmonary artery curves over the left main bronchus lateral and inferior to the aortic arch (Photos 9 and 10, Figs. 2 and 3). As it bends over the bronchus, the first branch arises from its anterolateral wall to enter the medial surface of the upper lobe directly above the left main bronchus (Photos 9 to 11, Fig. 3). The left pulmonary artery then curves acutely downward posterior to the upper lobe bronchus but anterior to the first branch bronchus to the lower lobe (Photo 14). At

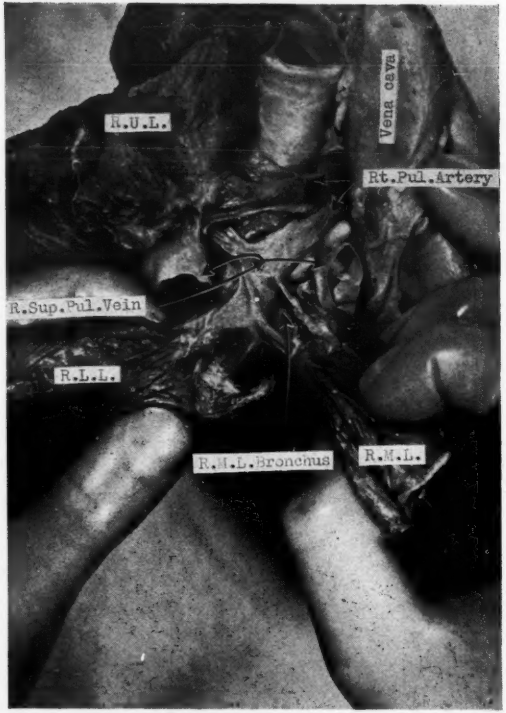


Photo 6.

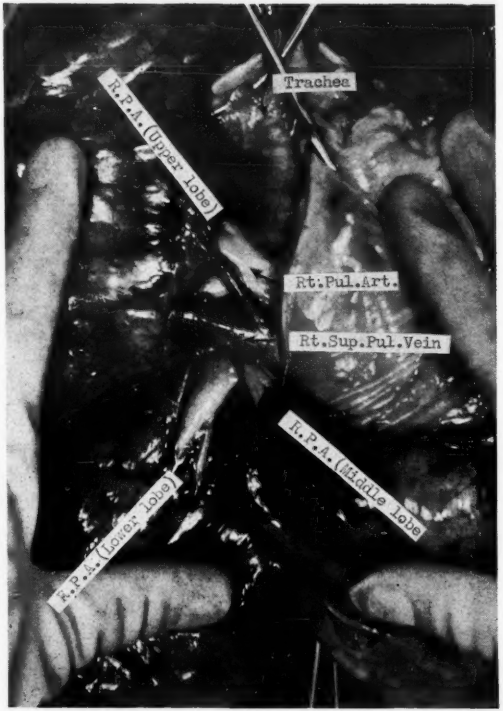


Photo 7.

Photo 6.—Right anterior view of the right pulmonary artery. The superior vein has been divided. Note that the vessels supplying the middle lobe come off posterior to its bronchus, and that the artery lies on the anterior surface of the right main and stem bronchi and not on the posterior surface. See Fig. 4.

Photo 7.—Right anterior view of a freshly dissected specimen. The right middle lobe has been dissected and displaced medially to show the pulmonary arterial supply. Note the position of the superior pulmonary vein which supplies only the upper and middle lobes in this specimen.

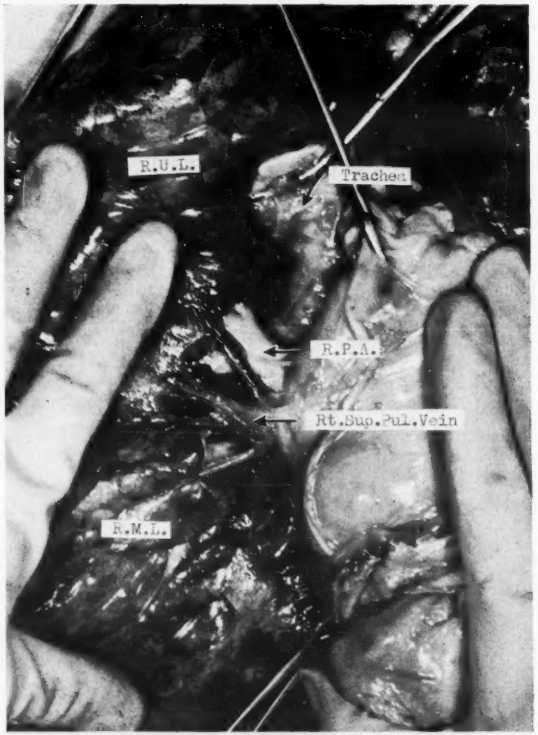


Photo 8.

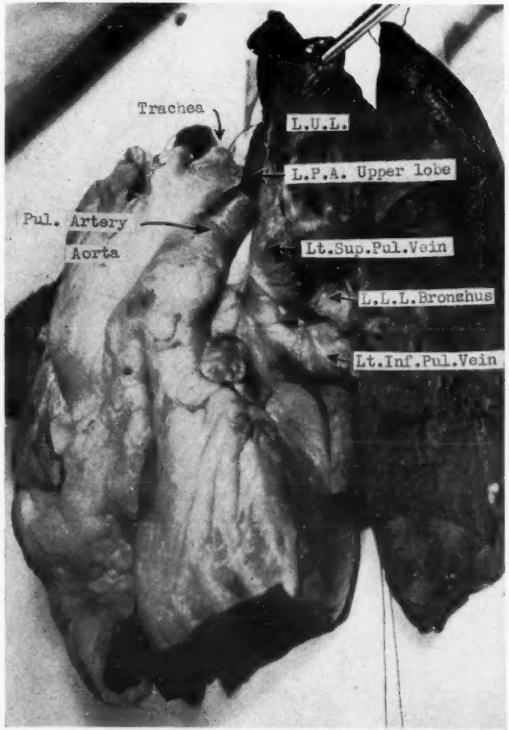


Photo 9.

Photo 8.—Right anterior view showing the branch of the right pulmonary artery to the upper lobe. The branch to the middle and lower lobes is not visualized as in Photo 7.

Photo 9.—Left anterior view of aorta and pulmonary artery and pulmonary vein. The first branch of the left pulmonary artery to the middle aspect of the left upper lobe is easily seen. The superior and inferior pulmonary veins form a crotch into which the bronchus and vessels fit. The same structure exists on both sides. See Figs. 2 and 5.

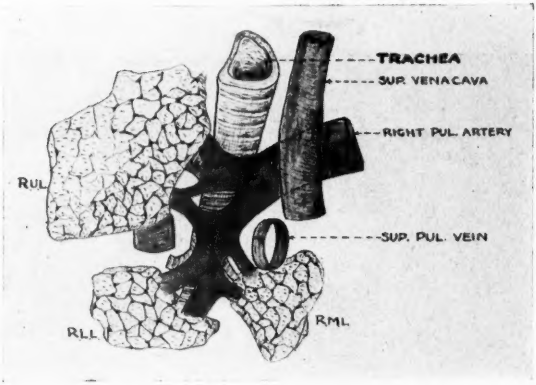


Fig. 4.—Right superior lateral view.

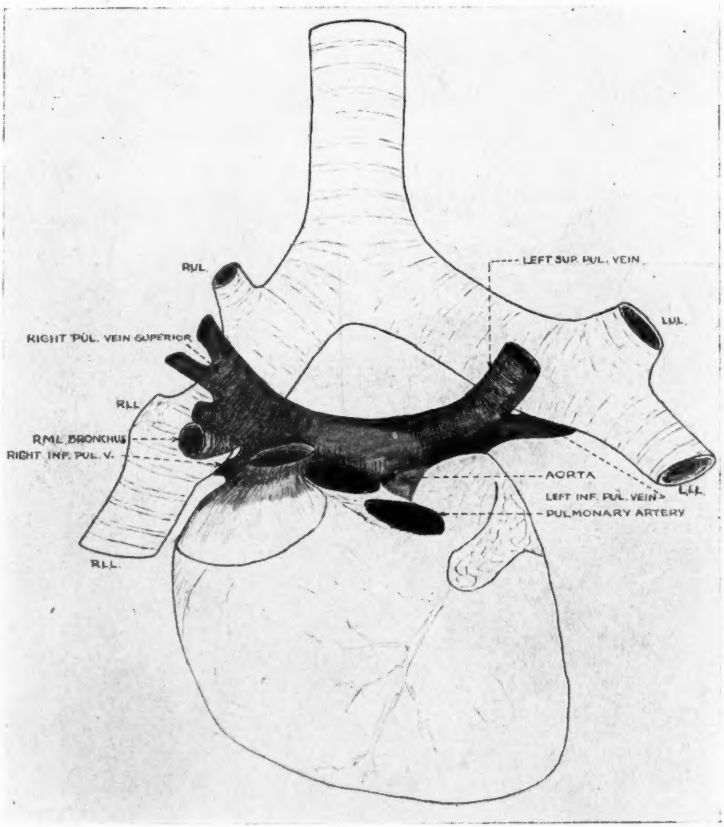


Fig. 5.—Anterior view.

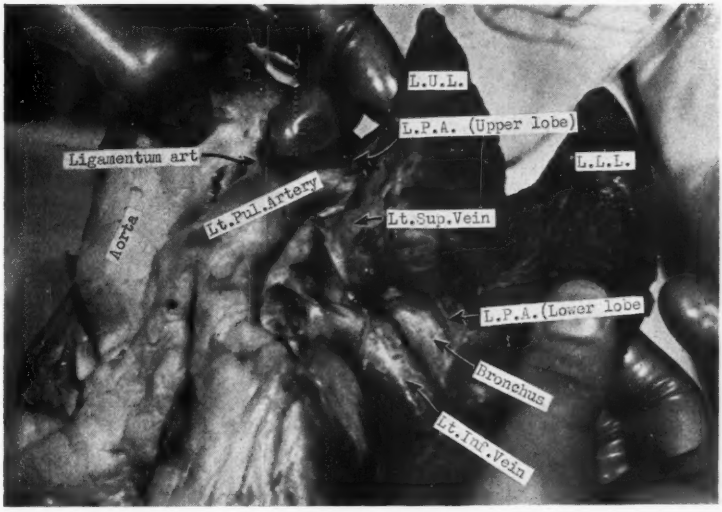


Photo 10.—Left anterosuperior view.

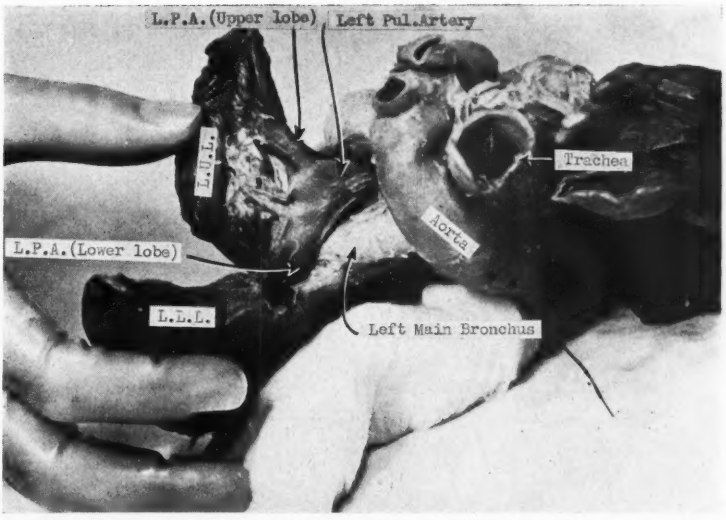


Photo 11.—Left posteriorsuperior view of left pulmonary artery. Note that the descending branch of the pulmonary artery is behind the bronchus to the upper lobe but anterior to the first branch to the lower lobe. From here the artery descends in the base of the fissure as seen in Photo 12.

this point the artery attains a position on the lateral and posterolateral surface of the stem bronchus by following the base of the interlobar fissure (Photos 11, 12, and 14, Fig. 3). In this area large branches from both the medial and lateral aspects of the artery extend to both the upper and lower lobes. It should be noted that some branches to the upper lobe arise at lower levels than the uppermost branches to the lower lobe (Photo 12). A rather constant branch drops down directly from the inferior surface of the left pulmonary artery as it arches over the left main bronchus. This arises at the level of the first branch to the upper lobe and supplies that portion of the lower lobe adjacent to the heart (Photo 13).

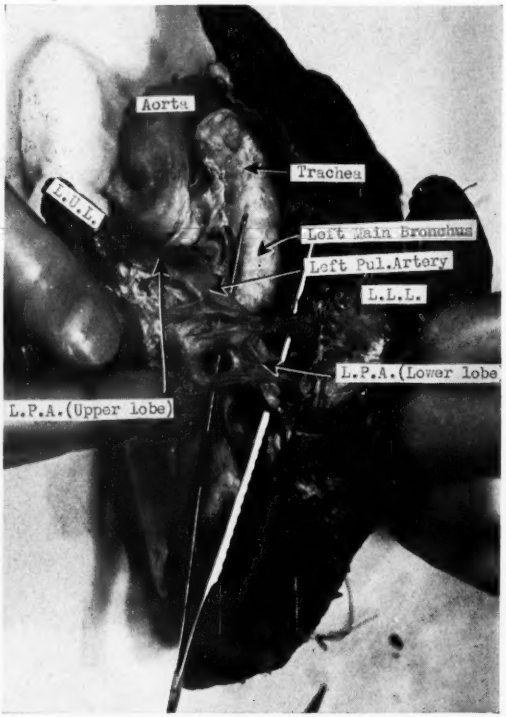


Photo 12.—View of left pulmonary artery obtained by separation of the upper and lower lobes in the line of the fissure.

Pulmonary Veins.—The division of the pulmonary veins into superior and inferior branches forms a crotch on each side into which the bronchi and arteries fit. The superior vein is anterior and the inferior vein is posterior to the level of the bronchus on each side (Photos 9, 10, 15, 16, and 17, Fig. 5). The right inferior pulmonary vein frequently appears

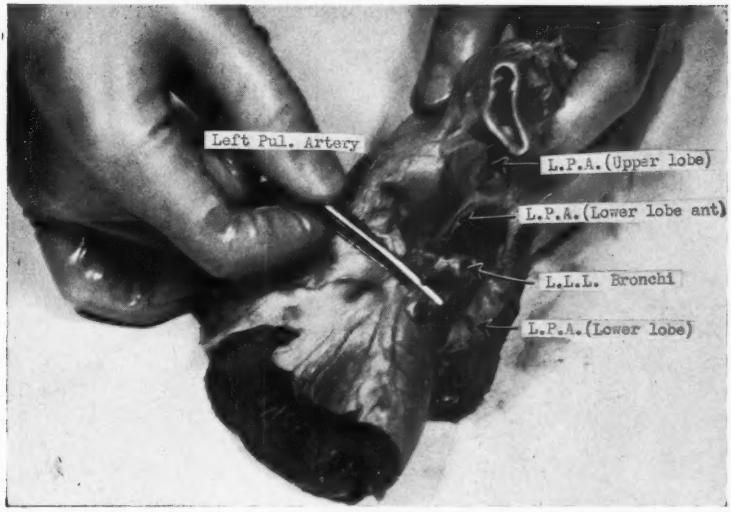


Photo 13.—View of left pulmonary artery showing the branch which lies anterior to the level of the bronchus. It supplies the portion of the left lower lobe adjacent to the heart.

Photo 14.—Posterior view of trachea, bronchi, and vessels. On the left side the pulmonary artery is posterior to the upper lobe bronchus and anterior to the first lower lobe bronchus; on the right side the pulmonary artery is anterior to the upper lobe bronchus and descends on the anterolateral aspect of the stem bronchus. The inferior pulmonary vein on each side lies posterior to the level of the bronchus.

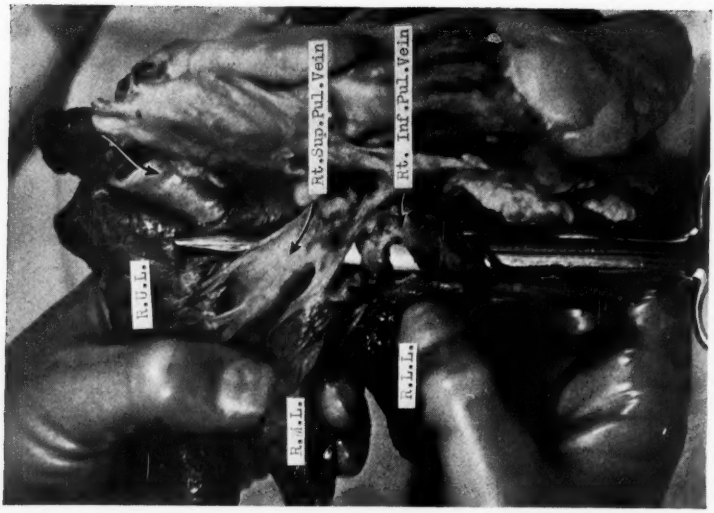


Photo 15.—Dissection of the right pulmonary veins. Note that the superior vein drains the upper and middle lobes while the inferior drains the lower lobes. The medial division of the inferior pulmonary vein frequently gives the impression of a double inferior vein.

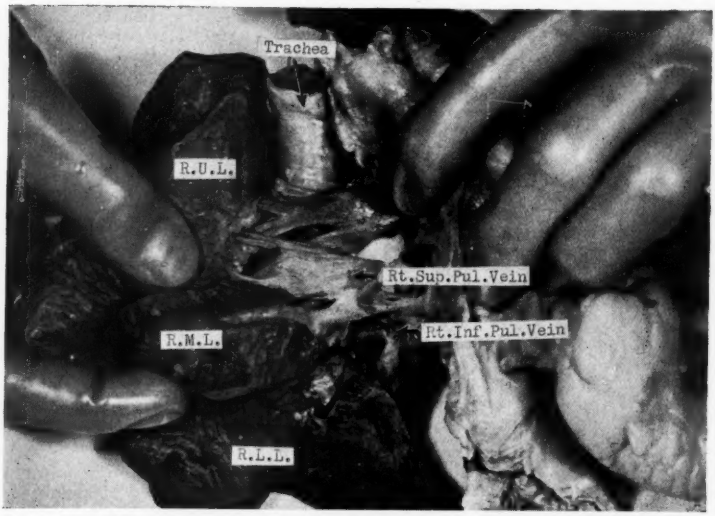


Photo 16.—View similar to that of Photo 15. The superior pulmonary vein covers somewhat the inferior pulmonary vein in the anteroposterior view. If the division of the vein is fairly lateral it may obscure the pulmonary artery.

to be double, but tracing medially usually reveals only early branching (Photo 15). The right superior pulmonary vein drains mainly the upper and middle lobes (Photos 5, 7, 8, 15, and 16, Fig. 5). The right inferior pulmonary vein, posterior to the bronchus, drains the lower lobe. Frequently it cannot be seen easily in the anterior approach since it lies somewhat posterior to the position of the superior vein (Photos 8 to 16, Fig. 5). The left superior pulmonary vein drains the

Photo 17.—View of dissected left hilus from below. Note the crotch of the pulmonary veins into which fits the bronchus.

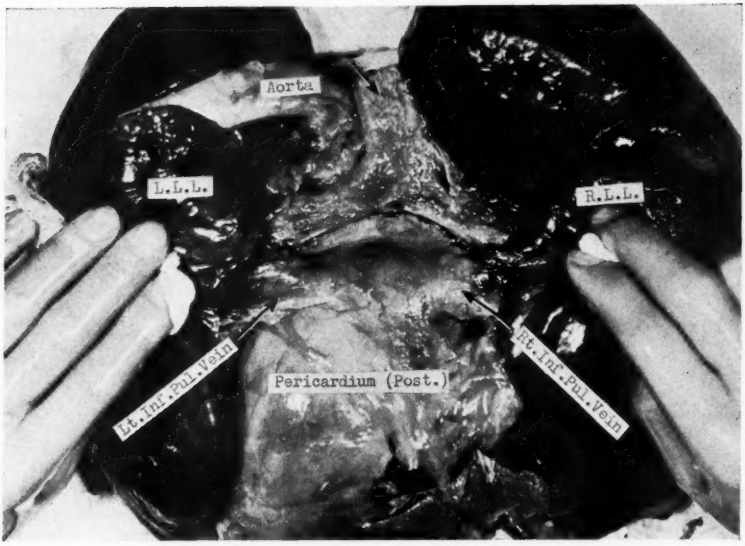


Photo 18.

Photos 18 to 23.—These photographs illustrate the approach of the pericardium directly to the hilus of the lung. Around the pulmonary veins the pericardial reflection may be overlooked. The formation of a cuff around the inferior pulmonary veins, particularly on the left side, constitutes a hazard unless the point of reflection is visualized.

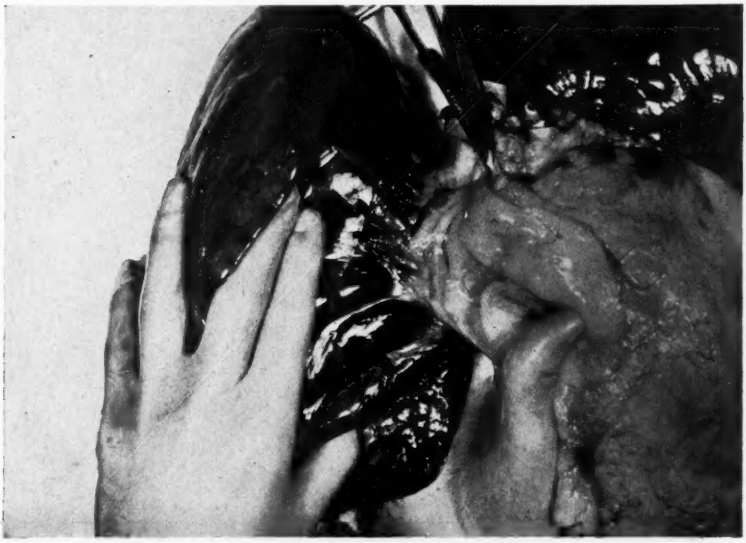
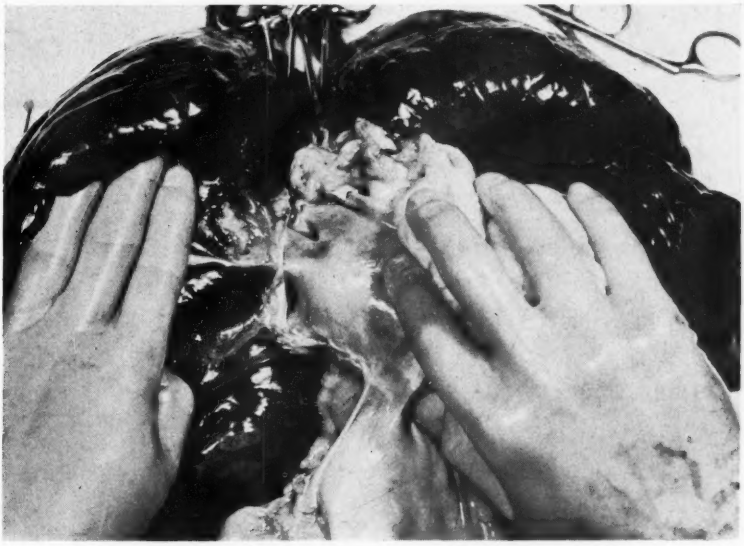


Photo 19.



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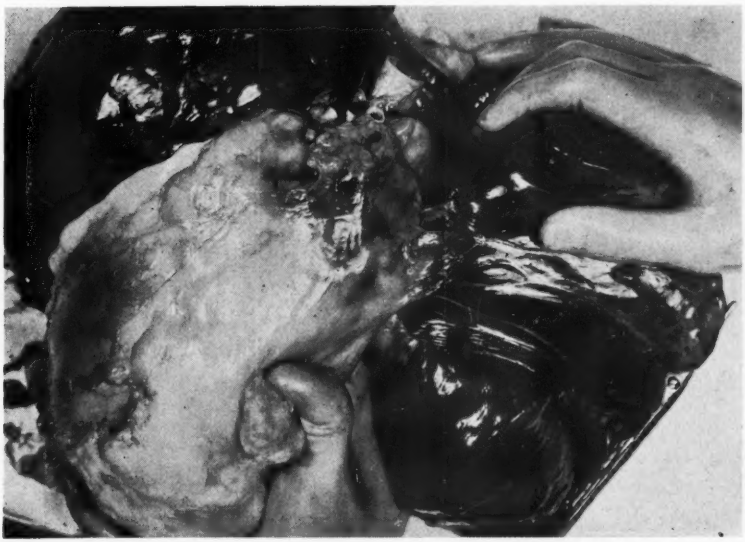

Photo 21.—For legend see page 540.

Photo 22.—For legend see page 540.

Photo 23.—For legend see page 540.

left upper lobe but may also send small branches to the upper portion of the lower lobe, particularly in that portion of the lower lobe which is adjacent to the heart. The inferior pulmonary vein drains the left lower lobe but it is less obscured by the superior vein than on the right (Photos 9, 10, and 17, Fig. 5).

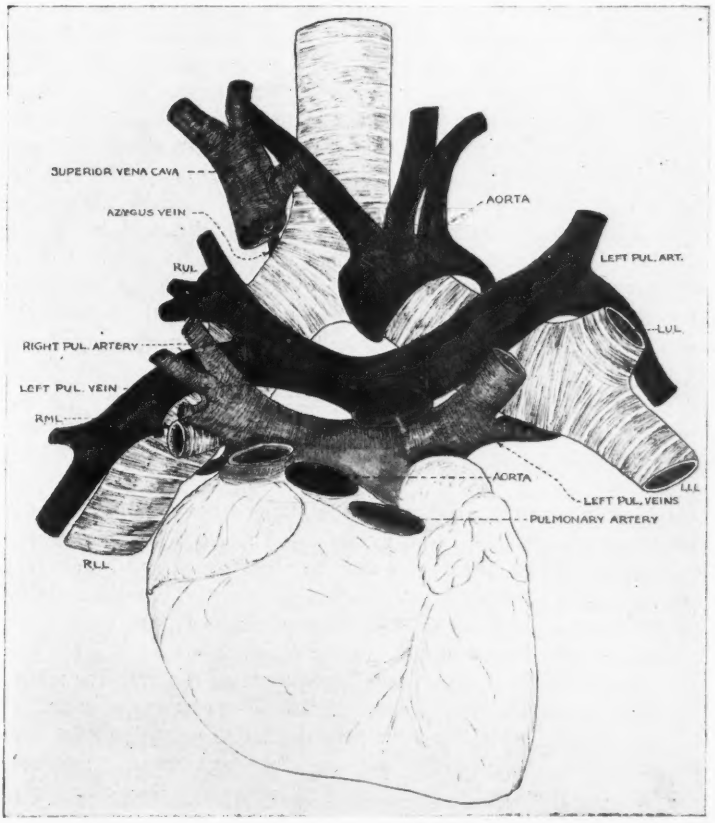

Fig. 6.—Anterior view. Composite drawing of vessels superimposed upon, on Fig. 1.

Reflections of the Pericardium.—The danger of opening the pericardium in ligation of the pulmonary veins makes the appreciation of its reflections important. On each side the pericardium extends well out around the pulmonary veins to the hilus of the lungs. It lies rather loosely around the superior pulmonary vein and is fairly easily identified. However, it fits snugly around the inferior pulmonary veins and particularly on the left side, where a cuff is formed, it may be readily overlooked and inadvertently opened (Photos 18 through 23).

PRELIMINARY PHRENIC-VAGUS INHIBITION IN THORACIC SURGERY

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BUENOS AIRES, ARGENTINA

THE existence of reflexes originating in the nerves at the pulmonary hilum has been proved both clinically and experimentally. These reflexes may affect the vascular system or produce changes in respiration. The vascular effects may be manifested by sudden drop in blood pressure, bradycardia, extrasystoles, auriculoventricular disassociation, and by ventricular fibrillation. Irregular breathing and apnea are common effects on the respiratory system. The intensity, degree, and severity of these phenomena vary considerably and cannot be foreseen. It can be stated, however, that rough handling of the hilum of the lung and the compression of the tourniquet about the root of the lung during an operation are the major causes in the production of the reflexes. Dissection of the pulmonary hilum and individual ligation of each structure will, therefore, reduce the incidence of the reflexes. We believe that in man the incidence and importance of these phenomena have been somewhat overrated by physiologists. Their effects are important, however, since shock and in a few instances death, have apparently resulted from the reflexes.

The most important reflexes are those that follow the paths of the vagus and produce sudden bradycardia. This sign is well known to anesthetists. Of less importance are the reactions caused by alteration of the functions of the sympathetic nerves, namely, a sudden drop in blood pressure and effects on the lungs which may later give rise to congestion, edema, and infarction of the organ.

The recognition of these reflexes has stimulated a search for methods to avoid or suppress their various effects. Narcosis might seem to be the best method but it has been proved that they still persist under deep anesthesia, though perhaps their effects are not so pronounced. O'Shaughnessey suggested and employed local nerve block at the pulmonary hilum. Vasconcellos of Brazil advocates complete functional denervation in intrathoracic operations. He accomplishes this by means of the physiologic action on the vagus of large doses of atropine and control of the sympathetic and spinal system with peridural anesthesia. His experimental work in animals has been applied successfully to man. Since 1940, we have performed preliminary phrenic-vagus inhibition at the level of the neck in a number of endothoracic operations (21 cases). This procedure has proved to be simple and harmless. Our clinical experience has proved to us that with our technique at least 50 per cent of the reflexes originating in the vagus will be inhibited. Since this

Received for publication April 9, 1942.

nerve carries the most important reflexes and our method abolishes all impulses except those which may travel through the anastomosis between both vagi, we have concluded that our method is of great practical value. Our clinical experience has demonstrated that with this technique we can manipulate the hilum of the lung or of the pulmonary lobes and even apply a tourniquet without serious cardiorespiratory embarrassment. In our opinion, manipulation carried out in any segment of the parietal pleura, such as freeing an adherent lobe, may cause much more serious and dangerous effects than similar manipulations about the hilum.

Most surgeons carry out phrenic inhibitions before intrathoracic operations; some do it inside the thorax during the operation, but the majority are in favor of a preoperative interruption of the phrenic nerve at the level of the neck. The latter is obviously more logical in view of the difficulties which may be found during the exploration of the thorax and a search for the nerve in its thoracic portion should there be pleural pulmonary adhesions present. Moreover, it is of great advantage to open the thorax when the diaphragm has already been rendered immobile. It is remarkable to witness the sudden mediastinal displacement caused by the arrhythmic diaphragmatic contractions and how quiet the field becomes after the phrenic nerve has been cut. The paralysis of the diaphragm also helps to decrease the mobility of the organs of the thorax, which has already been initiated by the preoperative pneumothorax. This becomes particularly important whenever an operation is contemplated in the neighborhood of the diaphragm, such as lower lobe lobectomies complicated by adhesions, thoraco-phrenicolaparotomies, diaphragmatic hernias, liberation of the lower end of the esophagus, and so forth. Since the phrenic nerve has anastomoses with the sympathetic system when it enters the thorax, and some of these branches are distributed to the pulmonary hilum, it is possible that phrenic sections have some bearing on the decrease of pulmonary reflexes.

Experiments carried out over ten years ago with the object of determining some of the physiologic effects of phrenic exeresis revealed that the phrenic nerve has an important role in the nerve supply through the pulmonary blood vessels and through the bronchial muscles. This would strengthen the hypothesis that the phrenic nerve may be involved in various reflexes originating about the pulmonary hilum.

Our operative technique has consisted of three joint procedures, namely, preliminary pneumothorax, phrenic inhibition, and vagus inhibition. We have been able to access the respective values of each procedure and have reached the conclusion that the transitory suppression, even in unilateral inhibition of the vagus influence, contributes to the disappearance of the harmful reflexes and inhibits the movements of the thoracic organs without respiratory arrhythmias or cardiac effects. This accomplished, there has been improvement during and after the operative procedures.

We have carried out physiologic section of the vagus at the level of the neck instead of following O'Shaughnessey who favored interruption of the nerves at the level of the lung pedicle. Our decision to attack the vagus in the neck was influenced by the same factors which have led to operations on the phrenic nerve at a high level, namely, ease and security in finding the nerve at that level and the fact that the intrathoracic effects will have already become apparent when the thorax is opened later. By using this method we have avoided the infiltration of large quantities of novocain about the pulmonary hilum which is particularly difficult when there are many adhesions present and the pedicle cannot be exposed until these adhesions have been removed. Protection is, therefore, afforded during the period that the resection of the adhesions is in progress and may eliminate reflexes caused by the handling of the adhesions.

Our technique is as follows. The phrenic nerve is located in the neck and the vagus nerve identified in the carotid sheath. Both of these structures can be reached through an incision in the neck or by infiltration with a needle through the skin, if novocain infiltration is to be employed alone. Should it be found necessary to carry out crushing of the nerve an incision is, of course, necessary. The vagus is always dealt with by infiltration alone. The novocain is injected into its containing sheath no matter which method is employed with the phrenic nerve. Since there is no danger in making an incision for adequate exposure, it is, therefore, usually advisable to employ this technique. This can be done a few minutes before the intrathoracic procedure is begun. After the phrenic nerve is isolated and cut or infiltrated with novocain, the posterior border of the sternocleidomastoid muscle is turned inward to show a fatty cellular structure which moves with respiration and also pulsates. This demonstrates the nearness of the vascular sheath. A fine gauge needle is inserted into the vicinity of the sheath in a horizontal position toward the midline. One must be absolutely sure that the needle has not penetrated into the blood vessels contained in the sheath before 10 to 15 c.c. of 2 per cent novocain is introduced. If infiltration of the vagus is to be undertaken through the skin, the best method is to inject about 10 c.c. of novocain under the sheath of the scalenus muscle. This muscle is easily recognizable through the intact skin and if the soft parts have been held tightly in position over it the needle provides a special sensation while passing through sheath of the scalenus muscle. The functional section of both nerves or the anatomic section of the phrenic are shown by their physiologic effects, that of the vagus by paralysis of its recurrent branch manifested by hoarseness, and the effect on the phrenic by the paralysis of the corresponding diaphragm. These signs and symptoms become apparent a few minutes after both nerve inhibitions have been carried out.

We only advise phrenic inhibitions by crushing if the patient has a carcinoma of the lung, and we have decided to perform a total pneumonectomy. This policy is followed because if the lesion is inoperable and the operation results only in an exploration of the chest, it is not worth while to subject the patient to the inconveniences derived from permanent paralysis of the diaphragm on account of the irreparable nature of the disease. Novocain injection of the phrenic will provide a total and transitory paralysis of the organ and allows for rapid recovery. It is true that with this method mobility of the muscle may not reappear for some time, but the method offers the advantage of continued tonus of the organ. It is well known that it is important to preserve the tone of the muscle in order not to alter the role of the diaphragm as a partition between the thorax and the abdomen.

The prolonged immobility of the diaphragm appears more often when an exudative pleural reaction follows the operation, or after dissections about the muscle to free adhesions, or after the diaphragm itself has been involved in the operation, as in cases of hernias, hydatid cysts, and so forth.

In cases where it is desirable for the whole lung to re-expand or in cases of lobectomy where the remaining lung tissue will fill the space, it is of utmost importance to preserve diaphragmatic movement and especially the tone of the muscles. After total pneumonectomies, where a permanent or transitory inhibition of the phrenic nerve has been accomplished, it is the rule that the diaphragm behaves as after a phrenicotomy, that is, it becomes paralyzed and is situated at a higher level, in spite of the tonus, that from the physiologic point of view is preserved, owing to the concentric force of attraction originating within the residual cavity.

The following is a list of cases in which the technique described to eliminate nerve reflexes has been used:

1. Bronchiogenic carcinoma: Total pneumonectomies, 3; lobectories, 2; exploratory thoracotomies, 6.
2. Bronchiectasis: Lobectomies, 4.
3. Benign tumor of the pleura, 1.
4. Cancer of the thoracic portion of the esophagus: Exploration, 1; removal, 1.
5. Diaphragmatic hernias, 2.
6. Mediastinal tumor: Removal, 1.

ACCESSORY PULMONARY ARTERY

Probably Arising From the Abdominal Aorta

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During the course of a left lower lobectomy, I was surprised to find a large arterial vessel which ran vertically from the diaphragm toward the lung and entered the lobe at the level of the hilum. The diameter of this artery was not less than 5 mm. and the jet of blood coming from the artery when it was cut was similar to that encountered when an ordinary bronchial artery is divided. There are not many accounts of accessory pulmonary arteries arising from the aorta. Batts published an interesting paper, in 1939, in medical literature, describing an accessory artery about 8 mm. in diameter which arose from the upper part of the celiac artery and ran in an upward direction across the diaphragm for a distance of about 9 cm., penetrating the lungs at the internal border of the right lower lobe. Batts recalls Magar's case described in 1802, in which the accessory vessel arose above the celiac artery and entered the thoracic cavity through the esophageal opening of the diaphragm and finally divided into two branches, one for the right lower lobe, the other for the left lower lobe.

CASE REPORT

The patient was a 15-year-old boy, suffering from bronchiectasis of the left lower lobe. When he was 5 years of age the left pleural cavity was drained, presumably because of a thoracic empyema. He recovered from this operation. At 12 years of age he began coughing and purulent expectoration occurred in the morning and when he went to bed. These symptoms lasted for about one year, with an interval of two months when he seemed to be cured. Three years later the scar at the site of thoracostomy started to swell and opened spontaneously. Pus drained from the incision. When the fistula closed expectoration increased, but as soon as the fistula opened again the amount of sputum diminished. His weight and appetite were normal so that the disease had not affected his general physical condition. Physical examination of the patient revealed a slight dullness in the left base, respiratory silence, and the absence of pulmonary movement in the same locality. There was clubbing of the fingers and toes. A bronchoscopic examination revealed pus in the left bronchus and the mucous membrane of the left bronchus was red and edematous. The pus was withdrawn by means of a catheter, and lipiodol injected into the left lower lobe. The

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Received for publication April 9, 1942.

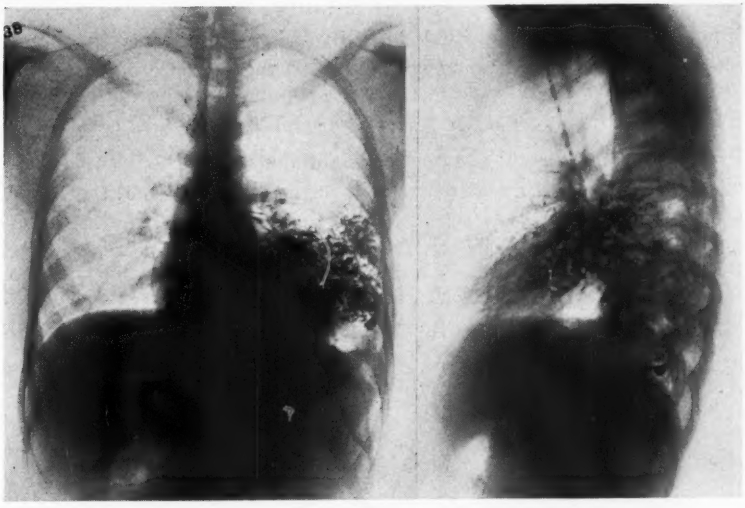

Fig. 1. Fig. 2.

Figs. 1 and 2 (R.G.).—Bronchoradiography with lipiodol; *1*, Front view and *2*, lateral view.

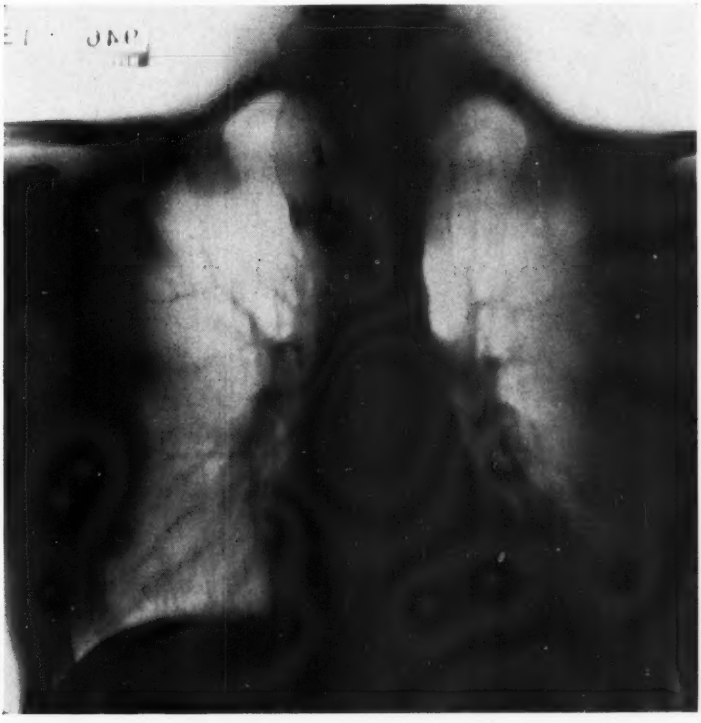

Fig. 3 (R.G.).—Azygos lobe?

lipiodol bronchograms revealed fingerlike dilatations in the left lower lobe (Figs. 1 and 2). Tomography revealed the presence of an azygos lobe (Fig. 3).

Lobectomy was performed on Aug. 23, 1941. The inferior surface of the lobe was strongly adherent to the diaphragm. During this difficult stage of dissection, a hole was made in the diaphragm and the defect was rapidly sutured. After the lobe had been removed the resulting cavity was thoroughly cleansed and the stump of the lobe's pedicle

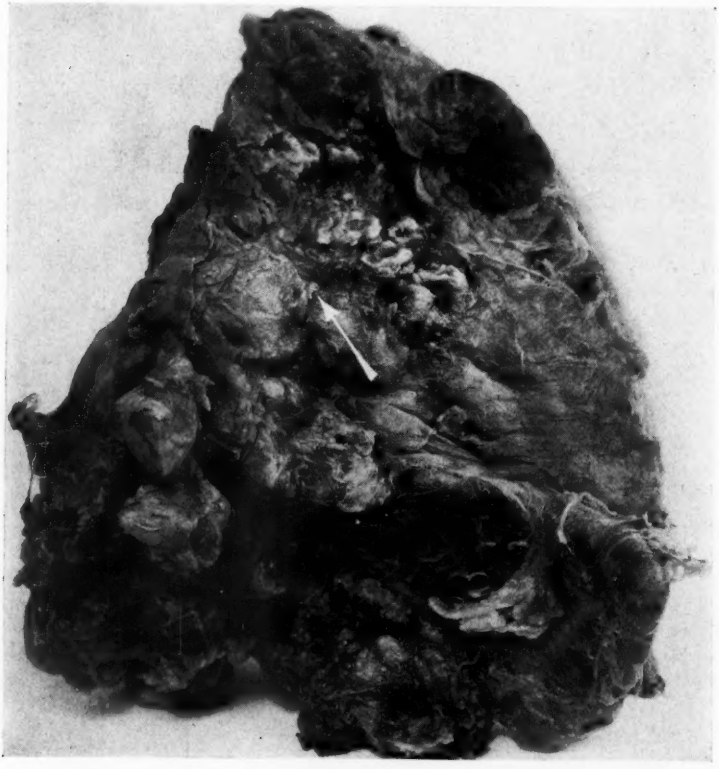

Fig. 4 (R.G.).—The arrow shows the place at which the artery cuts the lung.

sutured. Two artery forceps remained holding those structures found during the dissection; one of these structures was so large that it was more like an adhesion of newly formed tissue. We removed the forceps in order to get better hold of it and a large jet of blood similar to one from an artery appeared instantly. We replaced the forceps and noticed that the upper extremity of this supposed adhesion had an orifice with all the characteristics of a blood vessel. The adhesion containing

this vessel arose from the diaphragm about 2 or 3 cm. outside the pericardium's attachment to the central tendon. Without further exploration the adhesion was tied with catgut and the operation terminated in the usual fashion. The patient made a complete recovery from the operation.

The resected lobe was fixed in formalin and carefully examined. At the level at which the pleura is reflected to form the pulmonary ligament an abnormal vessel was found. The retracted yet widely opened orifice of this vessel can be seen clearly in Fig. 4 and even better in Fig. 5. The accessory vessel was not found during the dissection of the lower lobe because forceps had been placed on adhesions before they were cut. It

Fig. 5 (R.G.).—The arrow shows the accessory vessel.

is fortunate that we did not cut across it during this stage of the operation as it would have been difficult to stop the hemorrhage before the adherent lobe had been removed. Had there been no adhesions and since we systematically perform a preliminary pneumothorax, it is highly probable that the presence of the pneumothorax would have revealed the existence of this accessory vessel and therefore enabled us to carry out a more circumstantial exploration. This statement is based on the present case, in which we can only suspect the abdominal origin of the accessory vessel since we found it caught by the forceps which were placed on the upper surface of the diaphragm on adhesions between

this surface and the inferior surface of the lower lobe. We are able to exclude a possible thoracic origin of the artery. On the other hand, however, we cannot categorically state that the vessel arose from the abdominal aorta itself or from any of its upper branches (phrenic arteries, celiac artery, and so forth).

The patient has recovered fully from the operation and there has been no opportunity, therefore, to investigate the source of the vessel.

Though accessory pulmonary arteries are rare, the progress in endothoracic surgery which makes these operations more frequent directs attention to this important problem, since division or injury to one of these accessory vessels during the course of an operation might give rise to severe hemorrhage. This situation actually occurred in a case described by Harris and Lewis.[2] During the course of a lobectomy in which sharp dissection was necessitated by the presence of thick adhesions, an accessory pulmonary artery arising from the descending thoracic aorta was cut and the patient died. We thoroughly agree with Harris and Lewis that the subject of accessory pulmonary blood vessels is of greater importance than hitherto realized. During the course of endothoracic operations, particularly the cases of difficult lobectomies, the surgeon may be suddenly faced with an unforeseen arterial hemorrhage which calls for immediate and careful attention. It is my opinion that up to the present, the only way to guard against the presence of hemorrhage from accessory vessels is to systematically clamp all sizeable adhesions with forceps before they are cut.

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AN OPERATION PERFORMED IN ONE STAGE WITH INHALATION ANESTHESIA FOR HYDATID CYSTS OF THE LUNG, FREE OF ADHESIONS

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THE surgical treatment of hydatid cysts of the lungs has always been an important subject. Modern means of diagnosing pulmonary lesions especially with x-rays, has diminished the incidence of pulmonary suppuration associated with hydatid cysts because one sees and operates on a larger number of lesions before they become infected. Sometimes cases of small cysts are referred to the surgical services for treatment, their only clinical manifestations being hemoptysis and no obvious physical signs. It must be admitted that some patients with pulmonary hydatidosis may become cured spontaneously, but this cannot be counted upon even in a small proportion of cases. Moreover, during the time of waiting for spontaneous cure, surgical complications may arise and the surgeon will be obliged to operate under unfavorable conditions which might have been avoided. Furthermore, there is the fact which I wish to emphasize, namely, that the spontaneous cures observed in some cases may not represent real cures. This, in my opinion, must be considered carefully by the physician in charge of the case.

A few years ago the condition of hydatid cysts of the lungs was mentioned as a frequent complication secondary to tuberculosis. This was emphasized in a book published by Escudero[1] in 1912. Many other authors, particularly Lepicard,[2] have also studied the association of tuberculosis with echinococcus. (It rarely occurs.) However, in 1919, Escudero himself expressed an opinion that this association with Koch infections was less frequent than he had thought before. The same opinion has been expressed by other authors in their publications. Undoubtedly, these facts have been observed and verified by other men with extensive experience. I connect the frequency that is thought to exist between tuberculosis and echinococcus infection with the practice of avoiding operation and awaiting the spontaneous cure of the cyst. In this connection, I wish to mention that in recent years I have attended six patients with hydatid cysts of the lungs without infectious complications, cured by spontaneous coughing and emptying of the cavity. Of these six patients, whom I have followed closely for a period of one to five years, three have become tuberculous, one died, and the remaining two are under treatment, apparently progressing satisfactorily. It should be considered, therefore, whether or not tuberculosis is more frequent in

Received for publication Nov. 9, 1942.
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patients who have evacuated their cysts spontaneously, than in those who have undergone an operation and that the incidence of this complication seemed high at a time when the cases were not treated surgically with the same frequency as today. At least, this factor must be borne

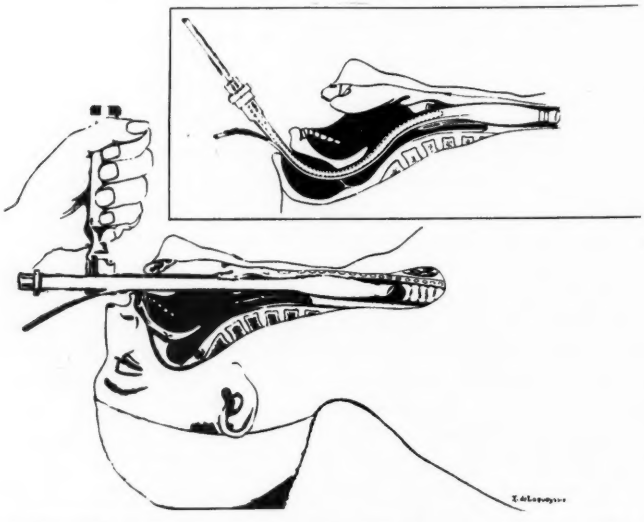

Fig. 1.—Inhalation anesthesia tracheal intubation either through the nose or the mouth.

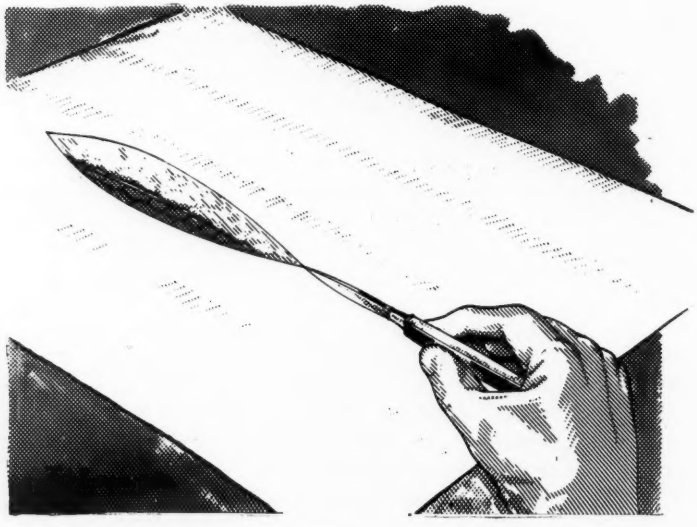

Fig. 2.—First stage, incision of the skin through subcutaneous tissue and muscles down to the ribs.

in mind, particularly when we might be considering the spontaneous development of a cyst. In the patients whom I have operated upon, I have had an opportunity to re-examine from time to time and have not found any case which has become tuberculous. I do not imply by this that a patient operated upon cannot become tuberculous, but my observation is worthy of notice. We often see, as I have said before, that cases of cysts reach surgical services without complications and without suppuration. They are commonly considered as clean cysts. These are usually present without pleural adhesions, sometimes even in cases which have undergone suppuration, but more often when infection

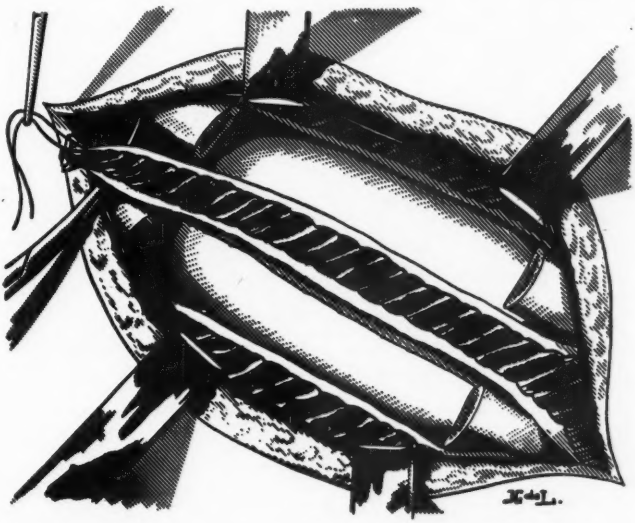

Fig. 3.—Second stage, resection of two ribs and intercostal bundle.

has not gone beyond the parenchyma. This situation has not been commonly seen before and in the great majority of a number of cases described by Lagos Garcia[3] of the Children's Hospital, seen over a period of more than twenty years, pleural symphysis was present. This does not occur, however, when the cyst extends into the parenchyma.

It is well known that in operations for hydatid cysts of the lungs difficulties may arise due to lack of pleural adhesions and pneumothorax which may be produced during the operation, the possibility of infecting the pleura, and finally the complication of anaphylaxis which may occur during the operation. With these complications in mind, we have adopted a number of operative methods which are designed to prevent complications which may arise in the pleural cavity when there is only partial or incomplete pleural symphysis.

The operative methods may be classified in general groups: (1) The operation performed in one stage and (2) the operation carried out in two stages. The first stage is designed to create pleural adhesions. The one-stage operation is known as Posadas' method. With this method, pleura and lung are opened at the time of the operation. This may be

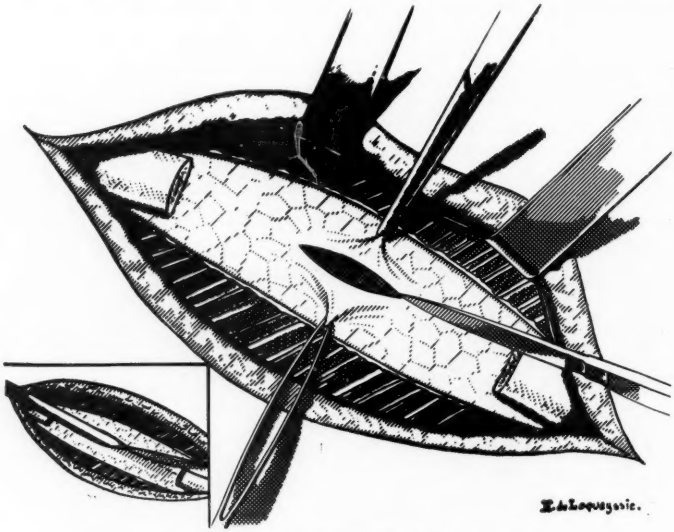

Fig. 4.—Third stage, opening of the pleura.

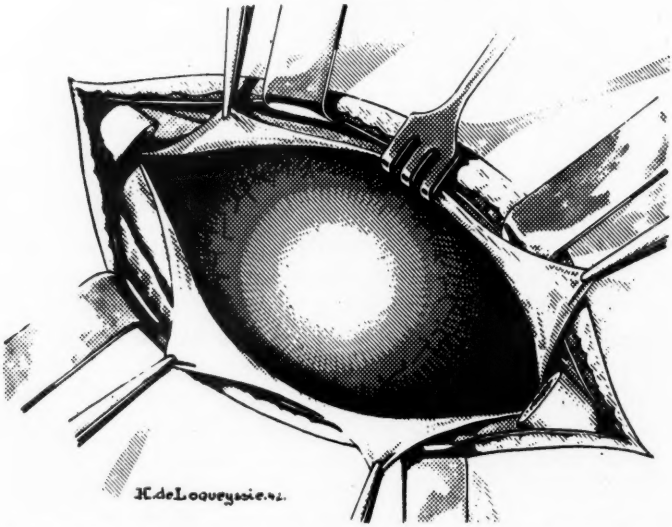

Fig. 5.—Fourth stage, exploration (the intratracheal pressure is slightly diminished in order to explore the lung to determine the presence of adhesions).

also performed with operative pneumothorax method, commonly known as the French method, although it was first proposed, if not carried out, by Andrés Llovet.[4] The operation may also be performed with inhalation anesthesia and control of differences of intrapleural and intrapulmonic pressures. This method is not widely known or used as yet and is precisely what I wish to refer to in this paper.

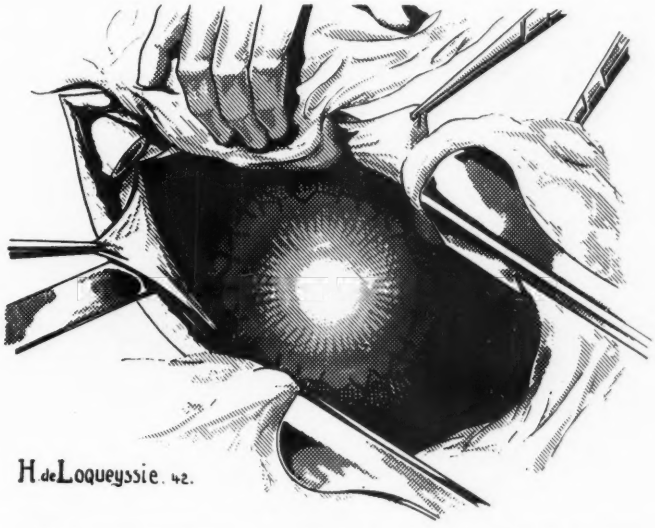

Fig. 6.—Fifth stage, operative field. Sheets have been soaked in mercurochrome solution; intratracheal pressure is increased in order to facilitate the puncture.

The operation with inhalation anesthesia to which I shall refer was originated by Sauerbruch,[5] in 1904, when he introduced his apparatus with the idea of using hyperpressure during operations on the lung. His methods were also used by Quenú and Longuet, Reclus, Tuffier, and others. In 1909, Melzer and Auer conceived a new anesthetic apparatus with the administration of the anesthetic agent through an intratracheal tube. The modern methods used today are the result of the ideas just described, an improvement in technique, and the invention of numerous appliances now in use. In 1914, in this country, Palma presented a report to the Society of Surgery of Buenos Aires dealing with an apparatus for the administration of anesthesia with hyperpressure.* He operated upon two patients with hydatid cysts of the lungs, employing this apparatus. In one case he used narcosis anesthesia increasing the intrabronchial pressure when the pleural cavity was entered. In the second case he operated with local anesthesia and administered oxygen with hyperpressure. These observations were not

*Manufactured by Davies.

published by Palma; we know about them through work published by Taubenschlag. We also know that these patients did well. After that period no other cases have been described in which the patients have been operated upon in this way.

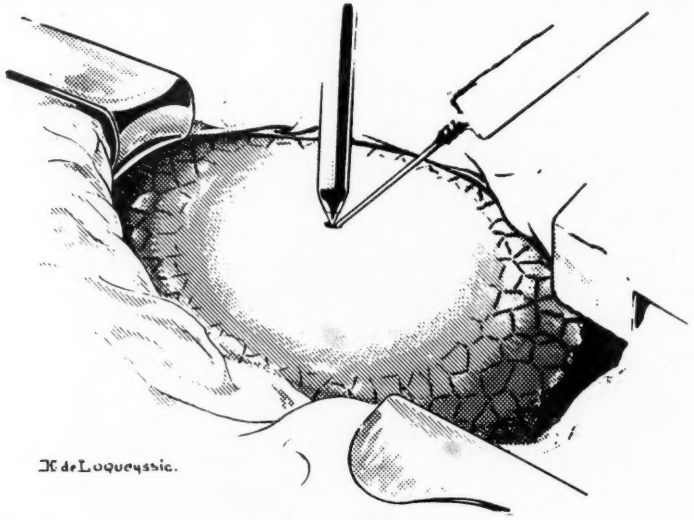

Fig. 7.—Sixth stage, puncture aspiration. Exploratory aspiration; trocar is introduced and the cyst is completely emptied.

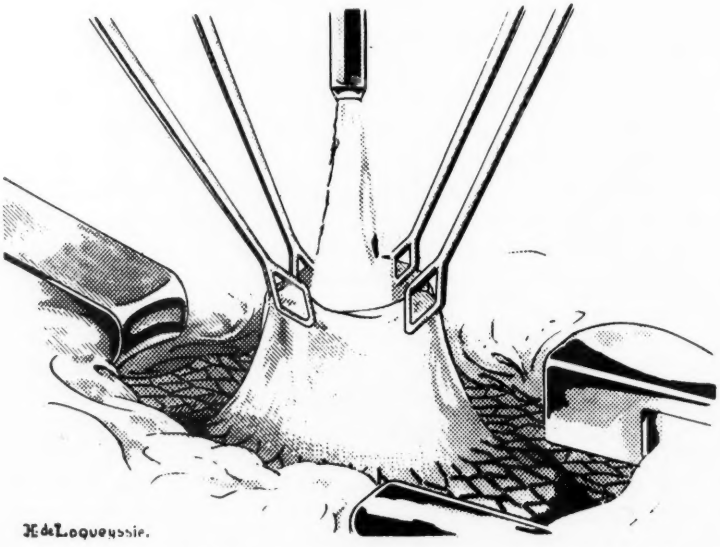

Fig. 8.—Sixth stage, aspiration of the germinative membrane; adventitia is held up by four clamps.

Makkas, a Greek surgeon, published in La Presse Medicale, 1938, an article referring to the operation in one stage. He carried it out with a preoperative pneumothorax. In the same article he states that in later years he has operated upon a few patients with hyperpressure, using Tiegel's apparatus, but he does not describe the technique or the manner in which he used the apparatus, neither does he give clinical histories.

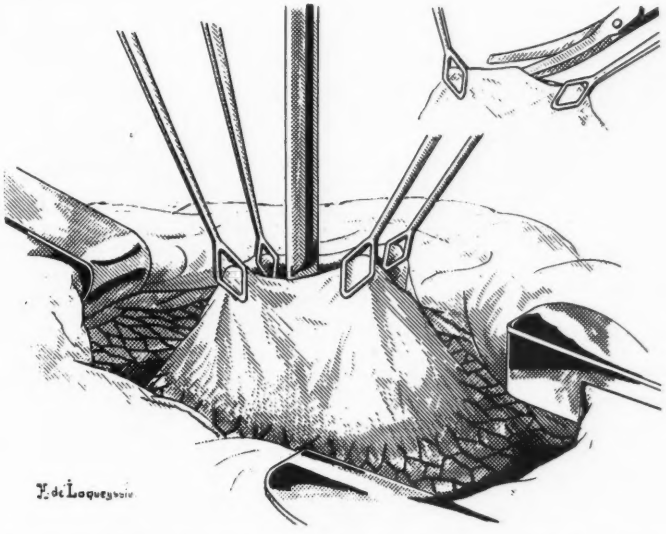

Fig. 9.—Seventh stage, the cavity of the cyst is carefully explored in order to find out if there are any bronchial fistulas.

In our surgical service in Buenos Aires we do not know of any cases published before ours in which the patients were operated upon with inhalation anesthesia. In 1936, we presented to the Society of Surgery of Buenos Aires our first case in which we administered cyclopropane with hyperpressure with a face mask and without using intratracheal intubation. Before that we had operated upon a series of patients with the same method and today we have twenty-four patients operated upon with inhalation anesthesia. All of these patients had hydatid cysts of the lung with a free pleura and in all cases there existed the danger of infection of the pleura. The object of the inhalation anesthesia was to counteract the pneumothorax that necessarily takes place when the pleura is incised and also to keep the lung in which the cyst is localized in contact with the operative incision. The production of an operative pneumothorax is not always a grave complication even though in some cases simultaneous complications have occurred. Today there are many surgeons who, according to their publications, operate in this

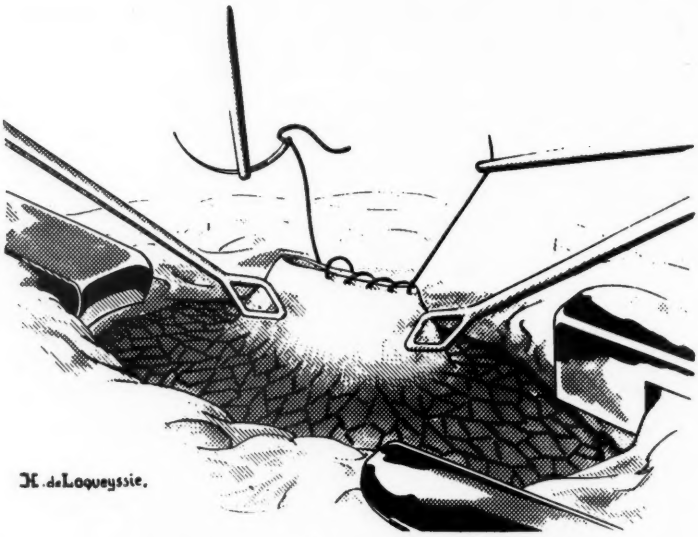

Fig. 10.—Eighth stage, the closure of the adventitious membrane; chromic catgut with continuous suture is used.

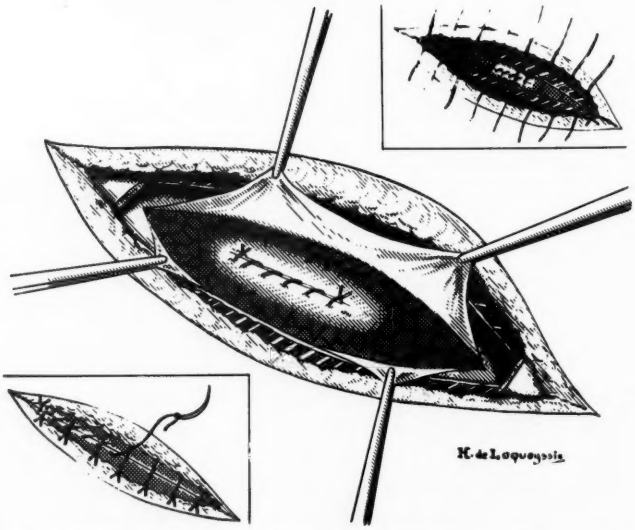

Fig. 11.—Eighth stage, continuous suture invaginates the adventitious membrane with chromic catgut and suture of the muscle layers.

way using different maneuvers but in general having satisfactory results. The method most commonly used to avoid operative pneumothorax was Posadas' method, that is, suturing the lung to the chest wall, emptying and closing the cyst. With inhalation anesthesia this maneuver is avoided. The cyst can be evacuated easily, and the cavity can be marsupialized and closed. In our opinion, this of great advantage. It does not leave a residual pneumothorax and the distended lung later occupies the pleural cavity in the same way as it normally does. In our actual experience, twenty-four operations have been performed on twenty patients. We have had only one death due to a pulmonary abscess and bronchial pneumonia. We had one patient who developed a purulent effusion in the pleural cavity, but it

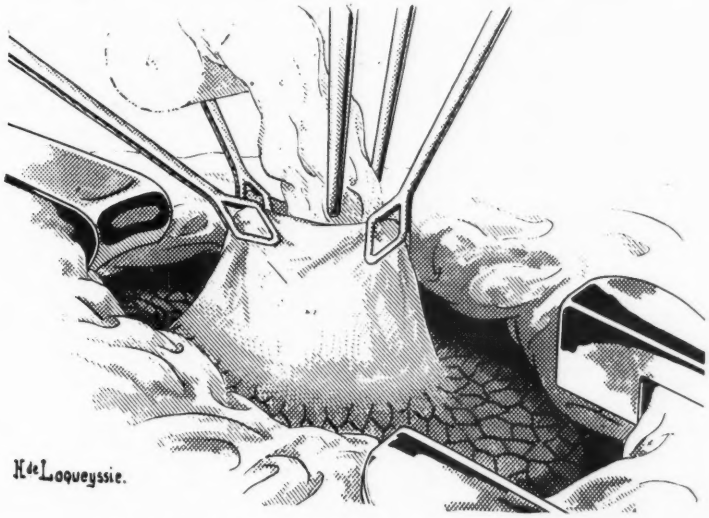

Fig. 12.—Ninth stage, packing of the opening of the cyst.

was not necessary to drain this. Later we saw four cases of nonpurulent pleural effusions that disappeared spontaneously. During the execution of the operation we did not observe any complications which might worry the surgeon. Neither suffocation, hemorrhage, nor emphysema have been noted as the result of hyperpressure anesthesia. We have also observed that the patients with multiple hydatid cysts who have been operated upon in different stages have tolerated the anesthesia with hyperpressure without affecting the other cysts existing in the lung. This is worthy of mention and consideration because while we operate on one cyst we might fear that the increase of bronchial pressure would influence the cyst in the same lung or even in the other lung. If we wish hyperpressure to be effective it is necessary to use intratracheal intubation. If not, the gas administered at a pressure of 15,

18, or 20 mg. of mercury may pass through the pharynx producing distention of the stomach. In our experience we have seen that hyperpressure through the simple facial mask does not distend the lung so completely as when the administration is carried out through a tracheal tube. Hyperpressure administered in cases of hydatid cysts of the lung presents some problems not encountered in other pulmonary diseases at the time of operation, because the cyst is filled with liquid and is subject to the changes of increased bronchial pressure. It is necessary, therefore, to graduate the hyperpressure and use it with caution. We have not observed the complication which is not uncommon in these cases, namely, suffocation from vesicles expelled into the mouth or dispersion of the vesicles into the pleura. With intratracheal inhalation anesthesia the operations are usually easy and uneventful.

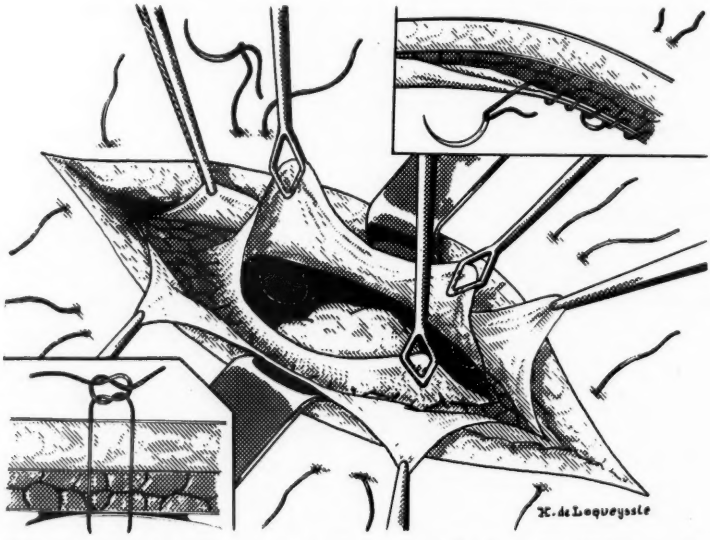

Fig. 13.—Ninth stage; this stage is called marsupialization. Six stitches are taken with heavy silk (mattress suture) in the adventitia, the muscle layer, the subcutaneous tissue, and the skin.

OPERATIVE TECHNIQUE

The first and most fundamental thing is the exact localization of the cyst. This must be done by the surgeon himself by means of fluoroscopy and radiography. The patient should be placed in the same position in which he is to be operated upon because change in position may cause a shift in the position of the cyst. The preparation of the patient has no unusual features and involves only those common to all major operations.

The existence or nonexistence of pleural adhesions cannot be affirmed in a categorical way before the operation. We can only presume

through the change in the cyst's shape, the history of pleural pain, and so forth, that pleural symphysis may be present. The presence of adhesions can only be established by preoperative pneumothorax, but this is of no importance in the technique to which we refer. There are some cases in which it is possible to determine for sure the existence of pleural symphysis. In these cases, the use of intratracheal inhalation anesthesia is not necessary. In the instances where we suspect the existence of these adhesions, we do not deem it necessary to investigate them with more or less complicated methods.

When we have localized the cyst and have placed the patient in the position for operation, the anesthetic is administered, first with a simple mask; then, when the patient is asleep, a tube is placed in the trachea by way of the nose. This is done easily and usually without trouble. If there are, however, certain obstacles caused by deviations in the anatomy of the nose, or any other reasons, the tube may be introduced through the mouth, which is equally simple. The intubation is usually done when the patient is asleep, but sometimes it is done when the patient is awake, following local anesthesia to the pharynx. There are still surgeons who carry out the operation in this way.

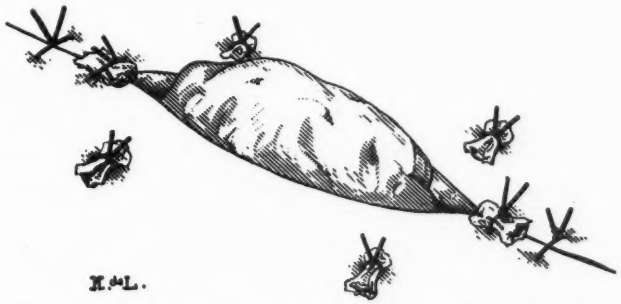

Fig. 14.—Tenth stage, suture of the skin and subcutaneous tissue.

As we have said before, when the cyst is localized, we proceed to resect a rib over the cyst. As a rule, the cysts of the superior lobes are approached anteriorly, the lesions of the middle lung fields through the lateral chest wall, and those of the lower lobes through the posterior chest wall. For cysts of ordinary size, the resection of one rib is usually enough, but when the cysts are small and more difficult to localize, it is usually more convenient to resect two ribs. After the ribs are resected, the pleura is opened and at that moment the anesthetist, to diminish the intrapulmonic pressure, permits a slight pneumothorax. If the cyst is not palpable and visible through the visceral pleura, this maneuver may aid in localization. Once the precise localization of the cyst is established the lung is again distended and there is usually no need to surpass 18 mm. of mercury in pressure. The cyst is then pune-

tured with Finochetto aspirator, using a medium-sized trocar and the aspiration of the liquid in the cyst is begun. This is quickly evacuated together with the germinative membranes or the daughter vesicles when they exist. The lung is kept inflated and if there are any bronchi of sufficient caliber to affect the intrapleural pressure, opening into the cyst, it is convenient to increase the intrabronchial pressure. The cavity is then plugged with gauze marsupialized, and closed in the way illustrated in Figs. 10 to 14. This plan is practical for all simple cases in which the cyst is peripheral or in contact with the thoracic wall. With those cysts termed "central cysts," in which there is a portion of parenchyma between the cyst and the chest wall, there are sometimes difficulties in the marsupialization. When the cysts are small, there is a tendency to close the wound without drainage. The trocar aspirator can be used in much the same manner as a harpoon and favors the traction of the lung toward the operative opening, even when the increase of intrabronchial pressure has a tendency to fix the lung. Cysts localized in the vicinity of the pulmonary hilum, with a considerable amount of parenchyma covering them, may be dealt with in this manner. The advantages of this method are that it considerably shortens the postoperative period, in comparison to the two stage procedure, and that it facilitates the operation more than the "harpooning method," which always presents some difficulty. It also favors the evacuation of the cyst. We have not observed bronchial overflow, suffocation, hemorrhage or effusion, or spillover of liquid or daughter vesicles into the pleural cavity in any case. The most outstanding advantage of the method is that all of the maneuvers necessary for the cure of the patient are performed in one operation.

In our personal experience, the method has resulted in a 4.16 per cent mortality in cysts free from adhesions. The risk is somewhat greater in adherent cysts, although in almost all of our adherent cases there was secondary infection or other infectious complications. It is necessary to stress again the importance of precise localization of the cyst, so that unnecessary aspirations will not be made because of miscalculation in the localization.

The method which involves two operations, first creating artificial adhesions, has been popular and sometimes has given good results, but it is necessary to state that in many instances the adhesions so created are not sufficiently firm to permit the second stage of the operation without difficulty. The method has been criticized for this reason by many surgeons.

No fistula remained in any of our twenty-three cases. The patient in our first case was operated upon five years ago. The pleura is undamaged and as has been expressed by Deve, secondary pleural echinococcus, due to operations for cysts of the lungs, is very rare.

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EXPERIMENTS IN INTRACARDIAC SURGERY*

II. Intracardiac Visualization

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FOR some time we have been convinced that intracardiac surgery is likely to become practicable. Once rendered safe for the patient and technically simple, the vast possibilities for such work need not be reviewed. We carried out a variety of intracardiac maneuvers on cats and dogs before our laboratory activities were altered by the war. Some of these operations have been mentioned previously and a detailed account of the production of experimental bacterial endocarditis has been published.[1] This simple experimental bacterial endocarditis may serve as a target for experimental surgical treatment of a disease now unsatisfactorily controlled by nonsurgical methods.

In the course of these closed or "blind" intracardiac procedures it is quite natural that we should have given thought to endoscopes.

INTRACARDIAC VISUALIZATION

Visualization has always been a problem in intracardiac surgery. The efforts of Haecker,[2] and Carrel and Tuffier[3] demonstrated that open cardiac operation and interruption of the circulation in dogs had to be limited to two and one-half minutes. Longer interruption of the circulation was fraught with danger of central nervous system damage due to anoxemia; still longer interruption was followed by death. This work makes it apparent that if serious consideration is to be given to intracardiac surgery for human beings, there are but three alternatives: The work must be done "blindly"; it must be done under some method of endoscopic visualization without prolonged interruption of the blood flow, or some temporary mechanical substitute for the heart and lungs must be devised. A review of the brilliant work of Gibbon[4] will convince one that the eventual solution to surgery of this organ lies in its isolation and open operation while the heart and lungs are short circuited with extracorporeal pumping and oxygenation of the blood.

Our interest is focused upon those surgical maneuvers that may be of value in the treatment of human disease and from this point of view there are a number of conditions that may possibly be attacked without awaiting perfection of the Gibbon apparatus. Even in these conditions,

*The cooperation and counsel of Dr. Timothy Leary have been invaluable throughout this entire study.

From the Surgical Research Laboratories of the Boston City Hospital, Dr. Stephen Maddock, director.

Received for publication Nov. 19, 1942.

it is true, however, that some form of visualization without interruption of the circulation, would be highly desirable.

Instruments have been devised for the purpose of visualizing the chambers and valves of the heart. Cutler and his co-workers[5] have called attention to an instrument used by Lawrence Rhea and I. C. Walker in 1913. This cardioscope was similar to a cystoscope and carried both a light and a knife. These workers did not report their work because of the failure of their animals to live. Cutler also used this instrument but its inset lens precluded satisfactory visualization. Allen[6] observed that when a heart was immersed in bloody fluid contained in a glass jar, those parts of the specimen in contact with the glass were visible whereas those parts insulated by the opaque fluid could not be seen. He then designed his cardioscope with a convex lens at its end enabling intimate contact with the cardiac wall and such areas thereby could be seen. This instrument, carrying not only the lens and light, also bore a knife and was used extensively by Allen and Graham.[7] Cutler also utilized the principle of the planoconvex lens for visualization on his valulotome.

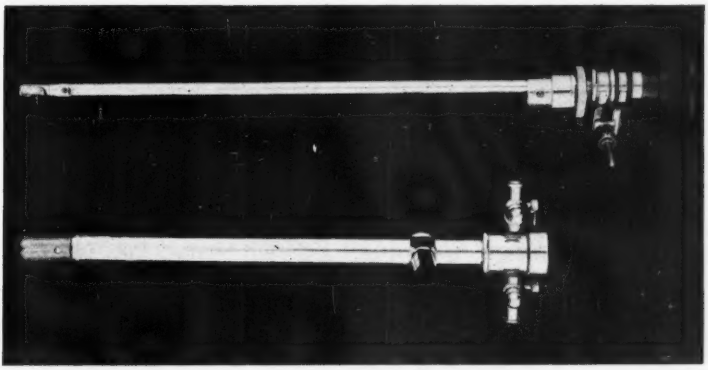

Fig. 1.—Above: The lens system and light of the Rockwood Keith Cardioscope. Below: The metal sheath of the cardioscope bearing a fulgurating post on the side and a glass displacement chamber at the end. (Note the fulgurating point on the glass displacement chamber.)

Recently, through the courtesy of Rockwood Keith, we have used still another type of scope. It was designed by Dr. Keith and Mr. Frederick Wappler[8] and constructed under the direction of the latter. This instrument carries a glass displacement chamber over a lens system similar to a thoracoscope with a right angle lens. It brings into the field of vision those structures in contact with the glass displacement chamber in front of the lens. It is particularly ingenious in that it also bears a fulgurating point in the field of vision. This instrument was designed by Keith for his experiments in the production of mitral stenosis[9] (Figs. 1 and 2).

It is perhaps fair to say that these instruments have given, at best, only limited vision. The principal difficulties have been due to the intermittent contact between the lens and the pulsating heart wall and to the small field of vision. The small field of vision is inevitable with either a rigid displacement chamber a few millimenters in front of the lens system or with the planoconvex lens directly applied to the wall. Even so, such instruments have been rather large and unwieldy for introduction into the living heart.

If the blood displacement chamber must be large while in the heart to afford a satisfactory field in vision, and small for insertion through the cardiac wall, it is apparent that a collapsible or elastic material must be used.

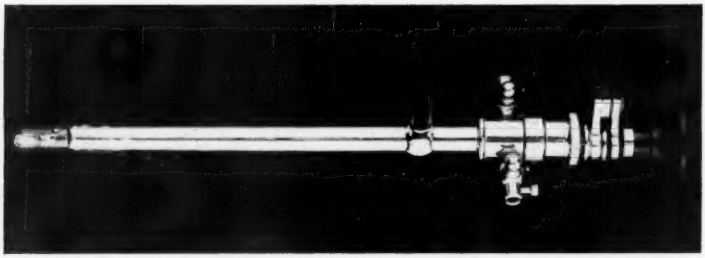

Fig. 2.—The Rockwood Keith Cardioscope assembled.

In casting about for an elastic, collapsible, and transparent material, we first used small latex rubber balloons. We were provided with latex rubber balloons dipped on a mold similar in size to the lens system itself.* In the undistended state these balloons were between 1/1000 and 1/1500 of an inch thick. Such a balloon could be distended with saline into a sphere two or more centimeters in diameter. In this distended state the latex wall was perfectly transparent. This balloon used as a displacement chamber, made visualization of the auricles simple but it was not strong enough to withstand intraventricular pressures. The use of stronger, thicker, latex rubber balloons was found to give unsatisfactory transparency.

Lamb,[10] in 1941, devised a rosin balloon for use in peritoneoscopy. This balloon fits over the peritoneoscope, is inserted through the cannula, and then inflated. It effectively displaces the intestines, making a more satisfactory exploration of the peritoneal cavity possible. Transparent collapsible balloons were obtained† in various sizes and shapes and used on the cardioscope presented here. More recently, one of us (E. M. G.) has successfully fashioned tough, collapsible, and perfectly transparent balloons in a variety of shapes from various plastics. Some of these are illustrated in Fig. 3.

*Through the cooperation of Mr. A. A. Glidden, director of research at the Hood Rubber Company.

†Through the cooperation of Dr. W. D. Coolidge, director of the General Electric Research Laboratories, and Mr. J. G. E. Wright of the same company.

Using such a plastic displacement chamber, the scope is inserted through the tip of the auricular appendage and maneuvered into position near the point of desired visualization. So placed, the balloon is distended with physiologic saline and as it comes into contact with the walls, or leaflets, the blood is displaced and the structures are rendered visible. This method of intracardiac visualization has impressed us as being more satisfactory than that possible with other cardioscopes. It has made visualization sufficiently clear that photographs and sketches have been made in the living animal. See sketches in Fig. 5.

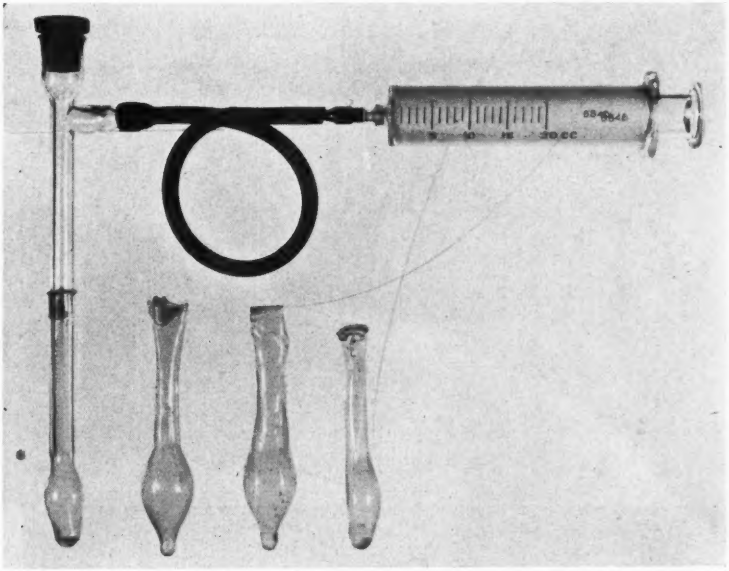

Fig. 3.—Our own cardioscope carrier and an assortment of transparent balloons.

THE CARDIOSCOPE

The cardioscope itself consists of three parts: the glass carrier, the balloon or displacement chamber, and the light-bearing thoracoscope (either foroblique or right angle) (Figs. 3 and 4). To assemble the cardioscope the neck of the balloon is pulled onto the shaft of the carrier and the thoracoscope is inserted into the carrier. The lens system is held in the carrier by a rubber cork. A rubber catheter connects the side arm of carrier to a 20 c.c. syringe filled with saline solution. Having exhausted the air from the scope the balloon is filled or collapsed by adjusting the plunger of the syringe.

THE USE OF THE CARDIOSCOPE

The assembled cardioscope, with displacement balloon collapsed, can be inserted readily through the auricular appendage. Hemostasis is

maintained by two opposing purse-string sutures about the tip of the appendage and closing upon the shaft of the scope. It is a simple matter to direct the end of the cardioscope into the auricle, through the mitral (or tricuspid) ring, over the valve leaflets, and over the

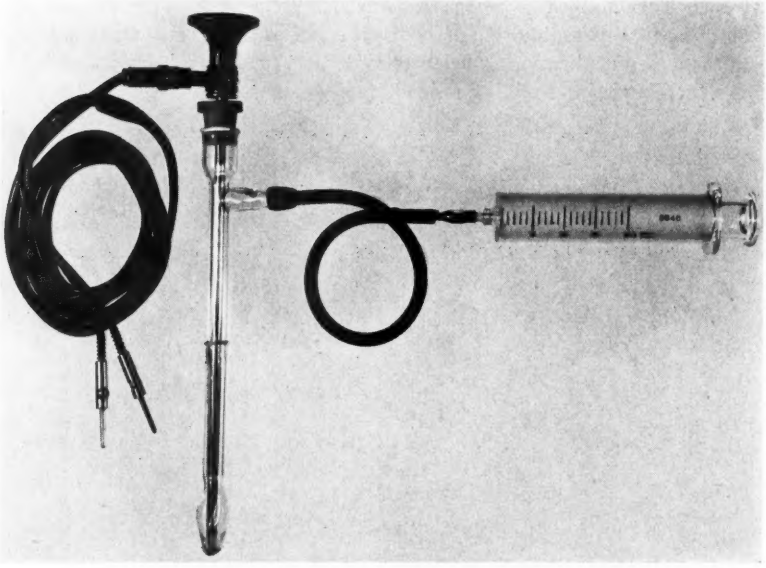

Fig. 4.—Our cardioscope assembled.

Fig. 5.—Sketches of three fields as seen through the cardioscope: Left: the posterior mitral leaflet margin; center: a papillary muscle; right: a pulmonary vein as it enters the left auricle.

endocardial surface of the ventricle. In each new location of the displacement chamber, the assistant holding the syringe gently distends the balloon with from 8 to 15 c.c. of saline. So distended, the balloon displaces the blood and comes into intimate contact with the various structures for inspection. The periods of balloon distension represent temporary circulatory obstruction so we have decompressed the balloon and allowed a circulatory recovery period of ten to fifteen seconds

between each observation interval of twenty to thirty seconds. The operator must have his assistant collapse the displacement chamber when moving the scope from one part of the heart to another. Neglect of this precaution may result in damage to the heart or in rupture of the balloon.

In the intermittent fashion described, we have observed the left ventricle and auricle of a dog's heart for as long as twenty minutes, with recovery of the animal; however, it has proved safer to limit the period of instrumentation and manipulation to ten minutes or less on the left side of the heart. Circulation can be interrupted on the right side of the heart for longer periods without unfavorable incident.

Details of the operative technique used in intra-auricular instrumentation can be obtained from a previous publication.[1]

COMMENT

Chevalier Jackson[11] has said, "In the future, as at present, the internist will tap and look and listen on the outside of the chest (and it is marvelous what diagnostic information is thus obtained); the roentgenologist will continue to look through the patient; but in a continually increasing proportion of cases, the surgeon, the internist and the roentgenologist will ask the bronchoscopist to look inside the patient."

Endoscopy, as well, has now carried into almost all organs. Cystoscopy, ventriculography, peritoneoscopy, sigmoidoscopy, thoracoscopy, and gastroscopy have all contributed to direct therapy and to our concepts of physiology and pathology. It is not too much to hope that some day corresponding contributions may be offered by cardioscopy. It is hoped that others may share with us our interest in developing safer and more efficient instruments for the examination of the cavities of the living heart.

SUMMARY

1. Brief reference has been made to the field of intracardiac surgery and intracardiac visualization.

2. Previous efforts at intracardiac visualization have been reviewed.

3. The Keith cardioscope has been presented.

4. A new cardioscope has been presented and its use has been described.

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POSTOPERATIVE DISTURBANCES OF RESPIRATORY MOBILITY

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LIFESAVING surgical intervention in pleural empyema is deeply impressive. The dangerous symptoms disappear as though by magic immediately after operation and the patient feels as though he were born anew. However, this rejoicing is often of short duration and a period of distressing sequelae supervenes, consisting of toxic symptoms, deformity of the thorax, and dyspnea, especially when recumbent. This symptom complex has become especially significant since dyspnea, deformity, and the impossibility of performing work entailing physical exertion make a resumption of the former activity difficult for patients with thoracoplasty for pulmonary tuberculosis.

The dyspnea of these patients has a peculiarity that gives a certain clue to its origin; their dyspnea is often markedly less when they stand or are seated than when they are recumbent, in spite of the fact that the respiratory apparatus is not changed anatomically by this change in posture. We must, therefore, conclude that functional factors play an important role. Fluoroscopy of the patients, with controls in healthy individuals, shows that changes in position cause marked shifts in respiratory movement of the chest wall. This static and dynamic shift is especially pronounced in the diaphragm. In the erect position the diaphragm drops down into the abdomen; in the recumbent position it rises into the thorax. The diaphragmatic excursion is much greater in the recumbent posture than in the erect one. However, in spite of this increased excursion, these patients are more dyspneic when lying down than when standing up.

The pathogenesis of this curious condition was explained through systematic studies of dyspnea and diseases of the respiratory apparatus. These studies showed that dyspnea in these cases was decisively influenced through dilatation of the pulmonary parenchyma. If atelectasis causes the air to disappear from the alveoli, or emphysema dilates them, the normal tension of the pulmonary tissue is changed and dyspnea caused in this manner. The physiologic tension of the alveoli and the elastic tension of the pulmonary tissue that goes hand in hand with it, is of basic importance for normal respiration. The normal emptying of the lung is caused by this elastic power, not because of activity of the

From the Theobald Smith Memorial Laboratory, Union University, Albany Medical College, Albany.
Received for publication Dec. 22, 1941.

respiratory musculature. The limitation of this intrapulmonary power of expiration causes the dyspnea of these patients, their orthopnea, that is to say the impossibility of sufficient breathing in a recumbent posture. This intrapulmonary elastic machinery is activated through the active inspiration. Inspiration changes the small, hard, anemic lung of the embryo, after a few breaths, into a large, soft, hyperemic organ. This change, however, remains only when the process of breathing is kept up without interruption. If a part of the lung remains unused for twenty-four to thirty-six hours, it returns to an atelectatic condition and the elastic power of this part of the lung disappears.

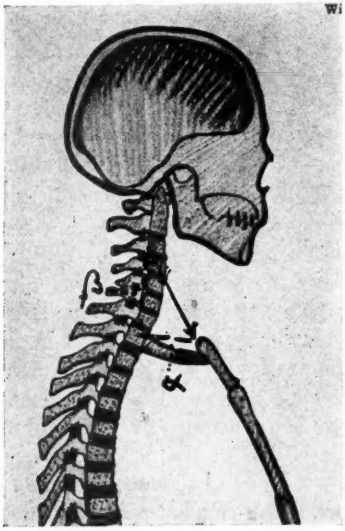

Fig. 1.

The thorax is also influenced through the activity of the inspiratory musculature, not alone during its inspiratory contraction, but also during the pause which occurs at the peak of inspiration; it does its work on the position of the rib cage. After cessation of contraction the living muscle retains a partial shortening, which is lost only if the work of the muscle is interrupted, for instance after thoracoplasty. After this operation the respiratory musculature is not activated and its tension lowered. The influence of the inspiratory muscles on the thorax is illustrated by Fig. 1. The scalenus anticus, like the arrow on the drawing, pulls on the rib from a point of the vertebral column that lies above, medially and posteriorly, and acts on the rib inferiorly, laterally, and anteriorly. Its action may be divided into the two components, alpha and beta. In case of a difference between the right and left sides, as after thoracoplasty, the beta component

causes a postoperative scoliosis. Aside from these changes that inform of the thorax, which are caused by displacement of the muscular insertions, the muscles have a formative influence on the bony rib cage according to Wolff's law. The diaphragm is also a powerful influence on the form and respiratory efficiency of the rib cage. Diaphragmatic adhesions to the lateral thorax often cause severe dyspnea and deformity. These changes are understandable when one realizes that the diaphragm moves away from the chest wall during respiration, but lies up against it when breathing stops. Scars which develop in the costophrenic sinus pull on the thin diaphragm with every breath, causing pain and making it difficult to breath deeply. These complaints are

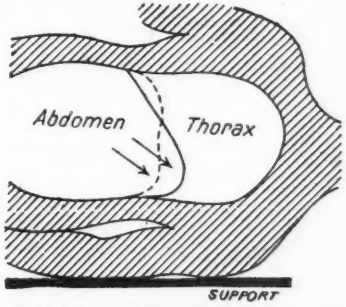

Fig. 2.—Dislocation of the diaphragm by bending.

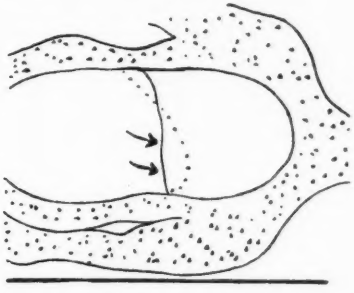

Fig. 3.—Position of the organ in a patient bending to the ill side.

especially pronounced when the costophrenic sinus is open passively, as happens in a lateral recumbent posture, or when the arm is raised. The position and movement of the diaphragm are changed in the lateral recumbent posture. The lower portion of the diaphragm rises high into the thorax. The other half sinks into the abdomen. This latter movement of the "upper" half of the diaphragm is accompanied by an almost complete immobility. The "lower" hemidiaphragm, on the other hand, shows abnormally large respiratory movements. These changes in the position and movements of the diaphragm occur in

healthy individuals without difficulty. If, however, there are adhesions between the diaphragm and the lateral chest wall as a result of pleurisy or operations, the resulting impairment of motion documents itself as a disturbance in respiration when the patient lies on his side. The thin

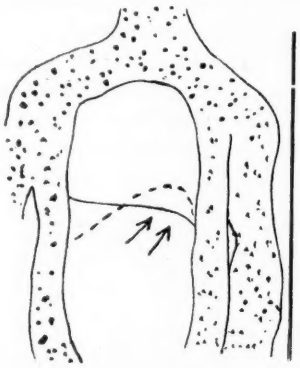

Fig. 4.—Position of the organ in a patient bending to the sound side.

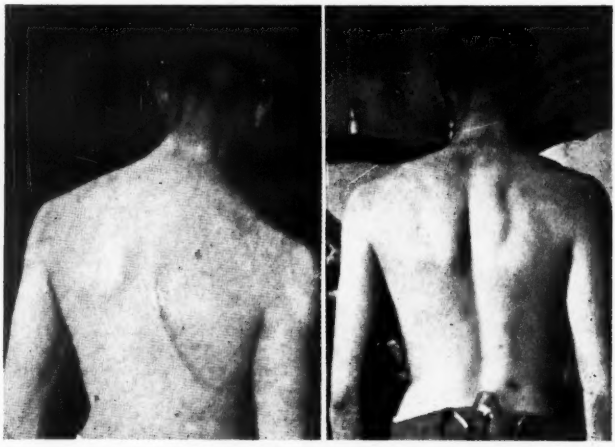

Fig. 5. Fig. 6.

Fig. 5.—X-ray of a patient before the respiratory treatment.
Fig. 6.—X-ray of the same patient after the re-education.

diaphragm is stretched through the weight of the abdominal viscera when the patient lies on the affected side. When he lies on the unaffected side it is prevented from separating itself from the bony rib cage by adhesions. This irritation of the sensory nerve fibers of the diaphragm causes various symptom complexes, according to the extent of the rigidity and the localization of the scars. Most generally recognized are difficulties of respiration and orthopnea in a recumbent posture.

They occur regularly with extensive adhesions in the phrenicocostal sinus. If, however, adhesions are thin and rigid, so that they pull the diaphragm out into a tentlike projection, severe reactions occur, syncope, oppression in the chest, sternal pressure, and a fear of impending death. The patient, therefore, avoids every change in position of the thorax, which he knows is followed by these unpleasant symptoms, sometimes ascribed to an angina pectoris. At times a peculiar neurologic symptomatology develops as a result of such adhesions, as a paralysis of the arm with descent of the scapula. They are caused by the pull on the phrenicocostal angle which accompanies elevation of the scapula. Dense, localized adhesions may cause an automatic reflex palsy of the arm and shoulder in the effort to avoid this painful motion. These thin adhesions are often difficult to see in the x-ray. The intrathoracic negative pressures are caused by the elasticity of the lung and chest wall. They are connected with the function of the affected part of the lung, that is to say, each part of the lung has a certain amount of elastic retractility according to its respiratory function, which does not affect the remaining parts of the lung. Therefore, if a diminution of respiratory function occurs over the operative field after a thoracoplasty, the effects of these changes remain limited to this area. From this point of view various shifts in the position and function of the thoracic viscera are intelligible: shift of the mediastinum, respiratory mediastinal shift, shift in the position and function of the diaphragm, etc.

These theoretic considerations illustrate many disturbances which we see at the bedside and also lead us to a causal treatment of the same. With this in mind a detailed study of the functional disturbances is imperative in each individual case. Especially valuable is exact fluoroscopy with tracings, which show graphically disturbances in the position and mobility of various parts of the respiratory apparatus, the chest wall, the diaphragm, and the mediastinum. It is necessary to make these tracings during the various respiratory phases and to incorporate them into the history. The results of treatment of these functional disturbances and the anatomic changes which are caused by them are often astonishingly good. With true consideration of all complex complications (painful sensations in the region of the scarry organs, irritative cough, rise in temperature, etc.), harmful reactions are avoided with marked improvement in the condition of the patients and perfection of the results of the surgical operation.

ARTIFICIAL PNEUMOTHORAX

A Nonstatistical Analysis of the Major Factors Involved in Its Proper Management

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ARTIFICIAL pneumothorax is the most widely used of all surgical procedures for the control and treatment of pulmonary tuberculosis. Among those experienced in its use there is almost unanimous agreement that, judiciously applied, it is of great value, in spite of the fact that in recent years several statistical studies[1, 2, 3] have been loosely interpreted as indicating that collapse therapy in general does not improve prognosis. On the other hand, it is true that no one can say exactly of how much value it is; this question may prove to be extremely difficult to answer because of the particularly complex and protean nature both of tuberculous disease and treatment. Indeed, when a statistical solution to the question was attempted in England a few years ago,[4] it became apparent that a completely sound approach from this standpoint could not be made. The factors which account for this difficulty are well recognized and need not be commented on here.

However, if accurate knowledge cannot be gained from mass studies of this sort, there is, nevertheless, a line of investigation on the subject which can be of great importance. This is concerned with the effort to make certain that when pneumothorax is used, it is used properly and in accordance with recognized modern principles. By its very nature, pneumothorax admits of countless variations in application and it is axiomatic in surgery that results of any therapeutic procedure depend primarily on the way it is used. A survey of the literature and texts on tuberculosis reveal that remarkably little attention has been given to details of management of pneumothorax; in fact, the implication carried in many of these articles is that it is the mere act of administering pneumothorax, rather than the way it is administered, which determines prognosis. It has been our experience, and it is the premise upon which this discussion is based, that results with pneumothorax do vary greatly with the way it is used, that there are right ways and wrong ways of applying it, and that, for this reason, its potential value will be fully realized only when it is conceived as a much more exact procedure than at present.

There are several distinct aspects of pneumothorax and the management of each should be governed by definite objective principles. It

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Received for publication, Jan. 28, 1942.

is the purpose of this discussion to outline these aspects and to describe, as concisely as possible, the various factors which we think contribute toward a more rational understanding of the procedure. Some of these are the result of recent technical developments (pneumonolysis, bronchoscopy), some are the result of analysis of our own past mistakes, and others are the result of applying to pneumothorax some ordinary sound surgical principles and a long-range viewpoint.

Among the basic aims of management are (1) the reduction of complications to an absolute minimum, and (2) the differentiation, as early as possible, between an effective and an ineffective pneumothorax. Neither of these is attainable unless surgical aid is readily available; in addition, pneumothorax must be conceived as only a part of the collapse therapy program. The focusing of attention on details of management should also connote that, in the future, unfavorable results which can be attributed to misuse will be recognized as such and not allowed to furnish the basis for a reaction against its continued judicious use.

It should be mentioned now that all reference to pneumothorax in this discussion assumes that it is combined with bed rest. We believe there is agreement that, from a strictly medical standpoint, mass ambulatory pneumothorax is a makeshift. It is of value but only within its limitations; its justification must be primarily on public health and economic grounds.

INDICATIONS

Indications for pneumothorax have been the subject of a vast number of articles and are undoubtedly phases of pneumothorax about which there will never be any general agreement. The reason for this is the fact that individual physicians vary in the interpretation which they place in the effect of the various methods of treatment used to control tuberculosis. This is a natural trait and will always be present. However, our observation has been that, within reasonable limits, this phase of the subject is of relatively minor importance, and that, other than to avoid extremes, the matter of indications is of far less significance than a knowledge of contraindications and of the details involved in proper management once pneumothorax is induced. It is sufficient to state that unless there are specific contraindications, cavity with positive sputum and progressive disease remain the classic indication for pneumothorax. In deciding on this question in any individual case, the possible dangers, inconveniences, and expense must be balanced with the probable benefits and especially the individual need for these benefits. This leaves much room for clinical judgment which is as it should be. However, in considering the problem of pneumothorax it is well to remember that a truism, applicable to all branches of medicine, is that unnecessary surgical treatment is to be avoided—that, therefore, in general those cases which will recover without major collapse therapy should be allowed to do so. Advocacy of this course in no way detracts

from the great value of collapse therapy; it merely recognizes the acknowledged fact that many cases of tuberculosis will recover without it.

MAJOR FACTORS WHICH MAY CONSTITUTE CONTRAINDICATIONS TO ARTIFICIAL PNEUMOTHORAX

There are certain conditions under which pneumothorax may be definitely contraindicated either temporarily or permanently even though collapse therapy is indicated. This aspect we consider of major importance.

1. *Type of Disease.*—It is well known that exudative disease retains the greatest proportion of its original power to heal and contract and it is, therefore, in these cases that the maximum benefits of pneumothorax are obtained. However, all disease of this type does not require pneumothorax. On the other hand, it is becoming obvious that in patients with disease which is almost entirely fibrous, and particularly when it involves the greater part of one lung, pneumothorax is usually definitely contraindicated. In these cases effective collapse is rare since adhesions are frequently numerous. In addition, the diseased area has already undergone marked scarring with a resultant decrease in the size of the affected lung. Thus, even if a fairly free pneumothorax space is found, re-expansion often fails to occur; if it does take place, it is usually only by shift of the mediastinum, thus increasing the size of the contralateral lung which eventually means emphysema and further diminution of respiratory reserve. In the vast majority of such cases which require collapse therapy, thoracoplasty is the procedure of choice. The result is usually permanent, there is very low mortality and morbidity, and few late complications. In addition to these important factors there is not the stress placed on the opposite lung as described above, and in the future application of collapse therapy this factor must be taken into consideration more uniformly.

In acute pneumonic tuberculosis it is wiser to allow a few weeks or months of bed rest before inducing pneumothorax in order to lessen the chance of serious pleural infection and possibly, by educating the patient on correct posture and methods of raising sputum, also to lessen the chance of bronchogenic spread of disease. There is much less to fear from adhesions since the perfection of details of closed pneumonolysis. It is realized that there is a great difference of opinion on the advisability of immediate pneumothorax in this type of lesion. It is, however, common experience that results gained with immediate pneumothorax have generally been disappointing; in the Negro they have been almost universally so. Although results are relatively unsatisfactory under any regime, the most effective course seems to be a period of bed rest usually followed by pneumothorax.

2. *Special Conditions Which Constitute Indications for Primary Thoracoplasty Without Attempting Pneumothorax.*—It has been thought in the past that pneumothorax should always be tried before consider-

ing thoracoplasty. However, there are certain types of lesions which should be regarded as unsuitable for pneumothorax and in which primary thoracoplasty is the procedure of choice. This indicates that not only is it thought that pneumothorax will not effectively control the disease but that, in addition, it may be definitely harmful. This stand appears especially justified in view of the safety, permanence, and low rate of complications which the modern thoracoplasty can show. Primary thoracoplasty is indicated when permanent collapse is needed,* when the chances of serious pleural complications with pneumothorax are prohibitive, or when interference with bronchial drainage makes pneumothorax dangerous. The more specific indications are these:

(a) *Large Apical Cavity:* Under these circumstances, pneumothorax should seldom be attempted. Adhesions which are nearly always present may contain part of the blood supply to the cavity wall and cutting them will often cause slough of the wall with resultant bronchopleural fistula and fulminating empyema. This puts a grave added factor on the patient, one which may in itself be fatal. In addition, with the very large cavities and extensive destruction, eventual re-expansion, even when possible, is not pleasant to contemplate so that from a long-range viewpoint permanent surgical collapse seems much the better procedure. Some of these cavities are difficult to close completely by any means. If the surrounding disease appears very exudative and the patient is toxic, a preliminary period of bed rest before surgical intervention is advisable. Otherwise, thoracoplasty is done with a minimum of delay. This course is also safest when there is extensive excavation throughout one lung. Permanent collapse is then desired and a temporary procedure (pneumothorax) should not be used unless the location of the disease is such that the more concentric collapse obtainable by pneumothorax is absolutely necessary for its control.

(b) *Extensive Fibrous Disease:* This contraindication to pneumothorax has been discussed under the section Type of Disease. As stated there, permanent collapse is best for the reasons given, provided, of course, that collapse is indicated by the presence of a cavity. Many of these patients have a great amount of resistance and may live for years in comparatively good health. However, thoracoplasty is often indicated as a combined economic and public health measure so that rehabilitation may be effected with a greater degree of safety to the public and, by the same means, permanent costly hospitalization avoided.

(c) *Bronchostenosis:* In cases of pulmonary tuberculosis complicated by encircling and stenotic disease of the bronchus, pneumothorax is usually contraindicated. Patients with such complications are prone to frequent bouts of high fever as a result of thick secretions collecting near the stenosis. Bronchoscopic aspiration will frequently terminate these episodes abruptly. However, induction of pneumothorax is often

*This is in line with what should be a basic principle of phthisiotherapy: to produce permanent collapse only through a measure designed for permanent collapse. Churchill[5] has brought out clearly the importance of this principle.

sufficient to convert a partial occlusion into a complete occlusion. As a general rule, primary thoracoplasty is the therapeutic procedure of choice although eventual prognosis must be guarded with any form of treatment. At least, by following this course, there is not an infected pleural space with which to contend. Thoracoplasty is indicated not only for control of the parenchymal disease but also because it may lessen the chances of pulmonary suppuration in the field distal to the stenosis. In a very small number of these cases, particularly those which show little active parenchymal disease, pneumonectomy may be indicated.

(3) *Presence of Active Tracheobronchial Disease.*—In the past few years a tremendous amount of knowledge has been acquired in this field. It is now realized that the presence of this complication may alter materially both the prognosis and treatment of tuberculosis and that, therefore, every effort should be made to diagnose it before active treatment is begun.[6] The diagnosis of tracheobronchial tuberculosis finally must rest on bronchoscopic visualization. However, there are certain signs and symptoms so strongly suggestive that they furnish valuable indications for bronchoscopic examination. Chief among these are the following.

(a) Positive sputum without obvious source. In many cases in which the parenchymal disease appears to be controlled but in which the sputum remains positive, ulceration of the bronchus may be found.
(b) Cyanosis and dyspnea without apparent cause.
(c) Marked daily variations in character and amount of sputum.
(d) Symptoms which are out of proportion to the visible parenchymal disease.
(e) Dense, homogeneous shadow of lobar or lobular distribution indicating wet or dry atelectasis. In many of these, the so-called classical signs of atelectasis are absent and are not necessary for the diagnosis.
(f) So-called "hilar flare" type of shadow in which the shadow appears to flare out from the hilar region. Included in this group are also those cases showing the greatest concentration of parenchymal disease around the hilar region.
(g) Wheeze, subjective or objective, but in either event a finding of great importance. It frequently leads to bronchoscopic examination and every patient should be questioned as to its presence and should also be examined for objective evidence of it.

Ulceration of the bronchus having been found, the question of treatment of the parenchymal disease then arises. If the ulceration is small and superficial, a fairly short period of treatment with 30 per cent silver

nitrate is usually sufficient to produce healing. In this case it is moderately safe to overlook completely the healed ulcer, and to proceed with whatever treatment appears indicated for the parenchymal disease. Aspiration of secretions at the time of bronchoscopy helps to make this safer.

However, if there is deep extensive ulceration, or, as mentioned previously, bronchostenosis, extreme hesitance must be shown as to inducing pneumothorax. In the latter, it is nearly always definitely contraindicated; in the former, there should be a preliminary course of bronochoscopic treatments of the ulcer and aspiration of retained secretions. If pneumothorax then is absolutely indicated by the presence of cavity or uncontrolled disease in an area which is not accessible to permanent surgical collapse, it may be induced with the hope that the preliminary bronchoscopic treatments may have lessened the chances of complications. But also it should be realized that under these conditions serious complications are frequent and indications for pneumothorax must be stronger than usual. There is often disease in the submucosa even when the mucosa appears healed and complications as described under Bronchostenosis are fairly frequent. Unexpandable lung, with all of its implications, is probably the most serious late complications. In the earlier stages, atelectasis is frequent but much more serious is the occurrence of anaerobic infection with excavation distal to the stenosis. Occasionally, the presence of excavations out of all proportion to the amount of tuberculous disease, and occurring shortly after the induction of pneumothorax, is the first indication of tracheobronchial disease. Particularly is this so in those cases in which the affected lobe quickly becomes solid.

Thoracoplasty effectively controls the parenchymal disease in most of these patients and is accompanied by few of the dangers inherent in pneumothorax.[7]

MAJOR FACTORS INVOLVED IN IMPROVED MANAGEMENT OF ARTIFICIAL PNEUMOTHORAX

A knowledge of how to use pneumothorax once it is induced shares equal importance with a proper conception of contraindications in determining results of tuberculosis treatment. Mastery of all the details involved in proper management requires a broad understanding of tuberculosis and constant attention to individual factors uncovered in each case as the procedure progresses. These factors are of paramount importance and unless pneumothorax is administered or supervised by one familiar with them, it becomes a haphazard procedure of doubtful therapeutic value and one capable of producing serious complications.

The more important factors essential to proper management are as follows.

1. *Early Re-expansion of Ineffective Pneumothorax.*—It is impossible to put sufficient emphasis on this point and it should be regarded as

by far the most valuable single means of improving the results of tuberculosis treatment. Every physician doing work on tuberculosis can recall failures of this sort from the past, many of which had tragic end results. It seems that the importance of this is still not sufficiently recognized even among workers in the field, since there are often seen, even now, and in good sanatoriums, cases in which pneumothorax is continued long after it is obviously ineffective. The disastrous results of this may be twofold: Not only does the parenchymal disease remain uncontrolled, but also there are created conditions favorable for serious pleural complications. Thus, many months are wasted, and quite often during this time the patient's clinical condition has been made worse by pleural tuberculosis and by bronchogenic spread from the uncontrolled disease in the underlying lung.*

The decision as to the effectiveness of pneumothorax should be made, in the vast majority of cases, in a few days or weeks. Frequently, an expiration film taken after the third or fourth refill will give sufficient information to make this decision. Early re-expansion can be effected with a minimum of serious complications, and in this way continuation of the procedure will be limited to those patients in whom it is therapeutically effective. Those in whom pneumothorax could not be effectively administered will have the benefit of prompt surgical treatment if indicated. Thoracoplasty is now highly developed and relatively safe and will be given to these patients early, while they are in good condition, and will be necessary only for control of the parenchymal disease. If, however, they are subjected to a long period of ineffective pneumothorax, they are usually faced with the necessity of such operative procedure eventually, but only after months or years in a sanatorium and often at a time when their general condition has deteriorated because of pleural infection, amyloidosis, or bronchogenic spread of disease. Operation, then, must often be performed to obliterate an empyema cavity which is far more serious.

2. *Proper Conception and Use of Closed Pneumonolysis.*—Recent studies have emphasized the value of free pneumothorax spaces in de-

*Failure to recognize that pneumothorax is not invariably beneficial or neutral in action but often is definitely harmful (partly actively and partly passively by delaying surgical collapse) has been responsible for most of the statistical confusion regarding the measure and for the ill repute into which it has fallen in some quarters. Evidence of the manner in which this may arise is found in the report of Jennings, Mattill, and Nemec,[8] in which therapeutic results were correlated with the type of pneumothorax space; with a satisfactory space 4.2 per cent were dead, with a partly satisfactory space 30.6 per cent, with an unsatisfactory space 66.2 per cent, and with no space 42.8 per cent. Thus, the fatality rate was approximately 25 per cent higher in those with an unsatisfactory space than in those with no space; paradoxically, the finding of a pneumothorax space made prognosis worse. Since the patients with an unsatisfactory space totaled 44 per cent of all their cases, an undifferentiated statistical study of pneumothorax (which is what most statistical studies are) would have resulted only in the beneficial effects being diluted and, in part, counterbalanced by the harmful effects and would have furnished no information as to the real value of the measure in those patients in whom it was effective nor of the real potential of collapse therapy in the entire group.

The obvious solution to such a dilemma is universal acceptance and application of this policy; unless pneumothorax is effective or through pneumonolysis can rapidly be made so, it should be abandoned promptly and alternative measures applied. Until that policy becomes an inherent part of pneumothorax therapy, further mass statistical studies will tend only to compound confusion.

termining the end result of pneumothorax treatment.[8, 9] It is inconceivable that a proper collapse therapy program can be carried out without having the operation of closed pneumonolysis always available. The technique has been improved so much that serious complications are now rare. An adhesion, per se, is not considered to constitute an indication for the procedure, but if there appears to be any tension through the diseased area, it is believed that the safer course is to have the adhesions severed. A large percentage of pneumothorax patients in sanatoriums should now receive this aid and it is undoubtedly one of the most important of modern developments. It is probable that the frequent use of this accessory procedure will greatly improve the end results of pneumothorax as in many of the cases in the past the diseased area was shown suspended by adhesions in such a way that really complete relaxation of that portion of the lung was not possible. In such a way, many cavities were thought to be closed only to show up again when re-expansion was permitted some years later.

There is no more reason for considering programs of pneumothorax without pneumonolysis as modern pneumothorax than there is for considering Brauer or other outmoded types of thoracoplasty as modern thoracoplasty, for each is a halfway measure.

X-ray films may be grossly inaccurate in outlining pleural adhesions even though many positions are used. If there is any doubt as to the operability of a case, thoracoscopic examination should be performed since this gives a far more accurate visualization than does the x-ray film. It was formerly believed that several months must elapse before pneumonolysis could be done. Now, however, the operation is carried out as soon as there is sufficient space, and it is easier, technically, at this early period. In ascribing complications such as simple effusion and empyema to this operation, it should be remembered that it is usually performed in the first six months and that it is in that same period that the majority of such complications occur even without operation.

While the very great value of pneumonolysis must be emphasized, there are also some contraindications to its use. There is now rather general agreement that the incidence of serious complications varies in direct proportion to the extensiveness of the operation. Therefore, re-expansion followed by thoracoplasty is usually preferable to an extremely extensive pneumonolysis. Of course, under certain circumstances this increased risk will have to be assumed, and this applies particularly to patients with advanced disease in the contralateral lung. As a general rule, however, very extensive pneumonolysis is contraindicated in unilateral disease.

The other set of conditions under which pneumonolysis should not be used is a large, peripheral cavity suspended by heavy, dense, adhesions. In many such cases the cavity wall receives part of its blood supply through the adhesions, and severance of them may cause slough

of the wall with serious pleural infection. Again, under these circumstances, re-expansion followed by thoracoplasty is preferred unless the condition of the opposite lung is such as to necessitate assuming this extra hazard.

3. *The Proper Conception of the Mechanics of Pneumothorax.*—This indicates that, fundamentally, pneumothorax is to be regarded as a procedure of relaxation and not one of active compression. Real compression pneumothorax is rarely needed and may do a great amount of harm. By giving frequent, small refills and performing pneumonolysis early, the diseased lobe will be allowed to concentrate into a smaller and more relaxed area. It is only in this way that "selective collapse" may be hoped for. Even this will not assure it, but rapid reduction of lung volume will almost certainly ruin any chance of it and, in addition, may tear adhesions and cause pleural infection. Especially in the more acute type of disease in which pneumothorax is used, rapid collapse may be disastrous. Likewise, very marked reduction of lung volume is usually neither necessary nor desired. The unnecessary collapse of normal tissue is a most potent source of late complications of pneumothorax.

The increasingly frequent use of pneumonolysis has made it feasible to carry out pneumothorax in this desired manner much more uniformly. In the past, contraselective collapse due to adhesions often made it impossible.

4. *Re-expansion in Cases With "Tension Cavities."*—Frequently cases are seen in which, even with the pneumothorax space anatomically perfect, cavities will remain stationary or even actually increase in size. In such cases they appear tense and assume a spherical shape, these being the so-called "tension cavities." The mechanism is commonly thought to be ball-valve effect at the cavitary bronchus allowing ingress but not egress of air. In this way, a positive pressure is built up within the cavity, and the pneumothorax seemingly serves only to aggravate the condition. In such circumstances it must be assumed that the pneumothorax is not only useless but actually harmful since many of these cavities promptly close with re-expansion. By recognizing this type of cavity and realizing the general ineffectiveness of pneumothorax in closing it, a useless pneumonolysis may also often be avoided. Cavernostomy may eventually become a real importance in these cases in which the bronchial factor predominates.

5. *Re-expansion of Effective Pneumothoraces When They Are Believed to Have Controlled the Disease Adequately.*—This is a problem that is admittedly hard to face, and the question of when to re-expand a pneumothorax often seems unanswerable. However, the present trend toward longer and longer pneumothoraces in all cases is not justified. It is believed that here again individualization is of utmost importance and that the amount of disease originally present, as well as several other factors, must be summed up in order to make the decision. But

it should be remembered that complications can occur at any stage of the procedure and, therefore, if the physician believes it has been therapeutically adequate, it should not be continued indefinitely simply because that is apparently the easiest immediate course to follow. Many cases of unexpandable lung result from the extremely long-continued pneumothoraces, and in many others there is "false re-expansion," which means that although the pleural space is obliterated, this has occurred only as a result of mediastinal shift. In certain instances this may have grave late consequences by producing emphysema of the contralateral lung with resulting respiratory distress.

By and large, the need for really prolonged pneumothorax is an indication of inadequate attention to choice of cases and the question does not often arise if the principle of primary thoracoplasty is accepted and carried through in patients with extensive tissue destruction, large thick-walled cavities and/or widespread fibrous disease.

MANAGEMENT OF COMPLICATIONS OF PNEUMOTHORAX

It is now widely realized that the successful treatment of pleural effusion or empyema requires intensive active efforts aimed at keeping the space as dry and as free of infection as possible.

We believe, however, that there is not sufficient recognition of the fact that cases showing either persistent clear fluid with symptoms or tuberculous empyema which does not clear promptly, represent potentially serious problems—problems which may constitute sufficient indications for prompt change of treatment. Not only may these factors cause severe, and at times rapid, deterioration of the patient's general condition but, through pleural thickening, they may predispose to ultimate difficulty in re-expanding the lung, thus being more insidious, but no less real, in their harmful effect. Under these circumstances the threat of the original parenchymal disease must be reappraised routinely so that a judicious decision may be made as to the justification for further continuation of the pneumothorax. In such cases, the availability of surgical collapse is to be kept in mind if re-expansion is done and the parenchymal disease proves to be uncontrolled. Reasoning along these lines, it may sometimes be found that in apparently controlled cavitative basal lesions, in other lesions which would require too extensive thoracoplasty or, in poor surgical risks, the continuation of pneumothorax, even though complicated by severe pleural infection, is justified. Under these circumstances, the increased danger is fully realized but is believed to be less than that of the uncontrolled pulmonary lesion which would probably appear with re-expansion.

On the other hand, in good-risk patients with unilateral disease confined to the upper part of the lung, these complications are almost always sufficient to indicate discontinuation of the pneumothorax, this to be followed by thoracoplasty if necessary. From a long-range viewpoint,

this course is usually much the safer one for the patient, and a long-range viewpoint is highly important under such circumstances.

It has been our experience that in the vast majority of cases, serious complications of pneumothorax can be ascribed to faulty choice of patients or to poor medical management; with meticulous attention to details, they become relatively uncommon. Tuberculous empyema, in particular, should no longer rate as a major problem.

The fact that most of the serious complications of pneumothorax are preventable is of fundamental importance and must receive more emphasis in the future. The factors involved in such prevention have been discussed under various headings. Briefly, however, they are:

(1) Early re-expansion of ineffective pneumothoraces.

(2) Recognition of certain definite contraindications to pneumothorax.

(3) Recognition of certain definite contraindications to pneumonolysis.

(4) Early, judicious use of pneumonolysis when not contraindicated.

MINIMUM STANDARDS FOR STATISTICAL STUDIES

The difficulty in obtaining really comparable controls complicates interpretation of statistical data in pneumothorax therapy. Nevertheless, this has not been the sole or even the major factor favoring the present state of confusion on the subject. Rather, this has arisen principally because there have been no standards to apply to cases going into such series. In other words, the term pneumothorax has been used as though it were strictly definitive whereas the measure itself has been used in ways anything but definitive. Thus, most statistical series comprise cases in which the term may mean anything or nothing. It may mean an effective pneumothorax or an ineffective pneumothorax; pneumothorax complemented by pneumonolysis when indicated or with no such aid; pneumothorax combined with adequate sanatorium care or largely ambulant. All these and other variations are included in mass studies and because there is this fundamental confusion as to what is being analyzed, conclusions cannot be anything but indefinite, vague, and, at times, misleading.

The logical remedy for this unsatisfactory situation would seem to be the establishment of certain minimum standards to be met by cases going into such series. The following are suggested as possible adequate standards which are still limited enough to be practicable:

1. Pneumothorax shall be combined with sanatorium care. Ambulatory pneumothorax must be recognized as a therapeutic makeshift from a strictly medical viewpoint.

2. Pneumonolysis shall be used as an integral part of the collapse therapy program.

3. Effective and ineffective pneumothorax shall be sharply differentiated and other measures substituted for the latter, which will then be considered an exploratory procedure, not therapeutic.

While these conditions are few in number, strict adherence to them represents the difference between a careful, logical, well-conceived program and one which may be haphazard, inexact, and capable of seriously complicating the whole course of tuberculous disease.

SUMMARY AND CONCLUSIONS

This discussion is offered in the belief that continued failure to establish and to emphasize adequate standards for artificial pneumothorax has constituted a fundamental defect of collapse therapy. For improved perspective now makes it clear that pneumothorax may act in widely different ways and that, as with most surgical procedures, therapeutic results are favorable only in proportion to the care exhibited in its use and to the faithfulness with which basic, objective principles are carried out. The corollary to this premise is that studies of a statistical nature which do not take into consideration the question of minimum standards are of little or no value in determining the actual potential of the measure.

I have outlined in as concise a form as possible the major points which, in our experience, have contributed toward a more rational understanding of pneumothorax. Some of these factors are the result of recent technical developments; most, however, merely represent the application of ordinary sound surgical principles. It seems probable that the widely divergent opinions as to the value of pneumothorax are mainly a reflection of the many illogical ways it has been used, that once the present loose conception of it is corrected and it comes to be used in such a way that the term pneumothorax automatically connotes an effective well-managed pneumothorax, then the controversy over its merit will largely disappear.

The application of collapse therapy along these general lines will result in a moderate percentage decrease in the use of artificial pneumothorax and a moderate to marked percentage increase in the use of thoracoplasty.

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MAJOR SURGERY IN AMYLOIDOSIS

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RECOVERY from amyloidosis is generally considered to be a rare event. In 1935, Reimann[1] stated "until Waldenström's report in 1928, it was generally believed that amyloidosis was a progressive and fatal disease." In 1940, Pearlman,[2] who has contributed much to the literature on this subject, refers to recovery from amyloidosis as an "extreme rarity."

However, as time goes on and more material accumulates from various sources it is evident that recoveries are more common than we have been inclined to believe, that recovery from advanced amyloidosis must still be considered rare, while in the milder state it is not uncommon. Differentiation should, therefore, be made between mild and advanced fulminating forms of the disease and also those which tend to become more chronic. The character and severity of the disease vary with the patient's ability to take care of excessive tissue protein destruction and the severity of the insult from the infected focus as well as the speed and effectiveness with which this focus can be eliminated.

The case herein reported, which represents the disease in its most severe form, tends to indicate that recovery was due to complete elimination of the source of infection. This has been the experience of other writers such as Reimann,[1] Waldenström,[3] and Rosenblatt.[4] The surgery performed in their cases, however, was of a minor nature.

This case illustrates amyloidosis in its acute phase and later in a more chronic state. It is well recognized that the disease may present a variable picture depending upon the stability of the amyloid substance. Grayzell[5] states, "On the other hand the longer the amyloid resides in the tissue, the more stable does it become; and the more difficult does it become to disintegrate and eliminate this material. This may account for the apparent retardation during the second stage in the resorption of amyloid."

In the present case every effort was made to eliminate toxic absorption during the acute phase and after accomplishing this the patient passed into a more chronic form of the disease when it was possible to proceed with major surgery and to eliminate completely the chronic empyema cavity which was the causative factor.

Following multiple thoracoplasties the patient has been clinically well for nearly two years and has been on a moderately active regime for this

Received for publication Feb. 8, 1943.
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length of time, having returned to his work as a laboratory technician. It is our belief that a considerable period of time must still elapse before complete elimination of all amyloid material is effected. That this has not been entirely accomplished in spite of clinical recovery is evidenced by the presence of albuminuria and a Congo red determination of 24.5 per cent in the blood after one hour.

We believe that our experience in this case should be recorded if for no other reason than that it may be of assistance to the surgeon who is considering operation in cases of amyloid disease. Although operations for drainage have been carried out in the past it is doubtful if any patient has been subjected to multiple major operations in order to obliterate the focus of infection. It has been the general belief that such procedures are unwarranted in the presence of advanced amyloidosis.

CASE REPORT*

J. H., a recent college graduate, was admitted to the State Sanatorium at Wallum Lake, Dec. 7, 1933, with active tuberculosis of the left lower lobe. Pneumothorax was started on the left side and was soon followed by the development of fluid which rapidly became purulent and was positive for tubercle bacilli. He was discharged in June, 1934. On Jan. 22, 1935, he was admitted to the Charles V. Chapin Hospital because it was stated that he was running a fever and the presence of fluid had become troublesome. He remained in the hospital until June, 1935. During this entire period the tuberculous empyema was treated by aspiration and replacement with 3 per cent gomenol. All sputums were negative for tubercle bacilli, but the chest fluid was positive during the early part of his stay, and heavily purulent. On discharge the fluid had become negative and was clear. The urine was at all times negative for albumin. Wassermann and Hinton tests were negative. Except for the chest, physical examination was not remarkable. There was no enlargement of the liver. The temperature, which on admission had ranged from 101° to 103° F., became normal and remained so for several weeks previous to discharge.

He was readmitted to Charles V. Chapin on March 16, 1938. Since his last discharge he had been practically symptom free. There had been no cough or expectoration. Weight was maintained and there was no reactivation of the pulmonary lesion in spite of moderate physical activity. X-ray of the chest showed density of the left side, which was believed to be due to fluid, but because of troublesome needle tract infections that had complicated his earlier treatments, it was decided not to repeat them at this time, especially as the patient was doing well. A few days previous to this admission the patient's temperature became elevated rather suddenly for no obvious reason. Aspiration of the chest was carried out and pus was obtained which was thinly purulent and

*Taken from the Thoracic Service of the Charles V. Chapin Hospital.

showed a pure culture of hemolytic streptococcus. No tubercle bacilli were present. Immediately upon admission the left pleural cavity was drained by an intercostal catheter, continuous drainage instituted, and constant lavage of the cavity carried out. This was followed by no improvement in his general condition; temperature remained elevated, there was evidence of marked toxicity, and in the days that followed profound anemia rapidly developed. On April 1, 1938, it was first noted that the liver was three inches below the right costal margin and the typical waxy pallor of amyloidosis became manifest. His red blood count, which on admission was 4,700,000 with hemoglobin 100 per cent, fell on April 2, 1938, to 2,210,000 and the hemoglobin to 48 per cent.

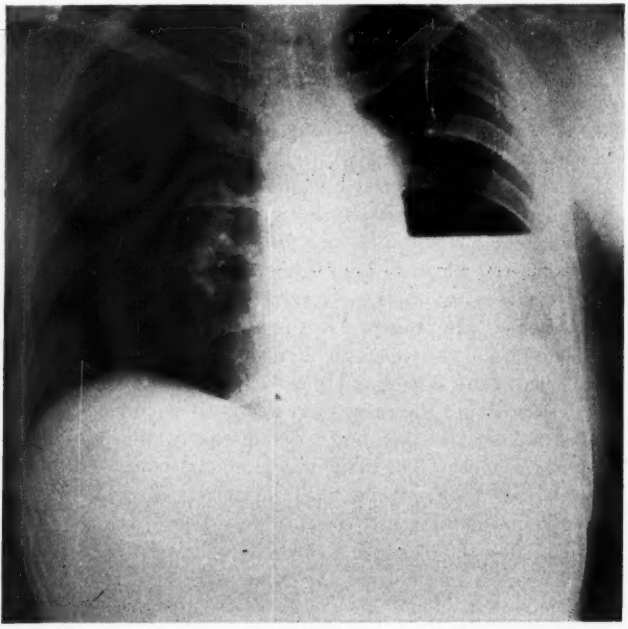

Fig. 1.—X-ray of chest (taken March 17, 1938) during the period when the patient was being treated for tuberculous empyema by aspiration and replacement with gomenol.

The urine showed 4 plus albumin, a few red blood cells and white cells and hyaline casts. The liver continued to become progressively larger until it was noted "the liver edge is down to the iliac crest, very firm and insensitive." Congo red tests during this time showed 100 per cent retention of the dye and the N.P.N. ranged between 30 to 40 mg. per 100 c.c. of blood. Urine boiled solid with albumin at all times and the specific gravity ranged between 1.005 to 1.010 with the presence of red blood cells and white blood cells usually noted. The liver edge remained at the level of the iliac crest during the remainder of the year.

Nausea and vomiting were persistent and there was marked wasting of the body. Frequent bleeding from the mucous membranes and the chest wound were very troublesome. He was at times *in extremis* and repeated intravenous fluids and transfusions were required to maintain life.

Toward the end of 1938, he began to show gradual clinical improvement. His temperature became normal and nausea, which had always been troublesome, was not so evident. His appetite improved and there was slow weight gain. Transfusions which had been given during the acute phase of the anemia were discontinued and he tolerated fairly well a high vitamin and high protein diet with liver and iron added.

The waxy appearance of his skin began to disappear and his general condition was better. His R.B.C. count rose to 3,500,000 and maintained itself without transfusions. On fine days he was allowed out of doors. The Congo red test, however, showed 0 to less than 5 per cent in the blood after one hour and the liver edge remained at the level of the iliac crest and showed no evidence of regression.

During the year 1939, gradual improvement continued. He gained weight slowly and was able to walk about for a limited amount each day. His blood cell picture approached normal. The pleural cavity was kept on constant drainage, and suction was maintained with the hope of diminishing the size of the cavity. It was thoroughly irrigated at least twice daily with various solutions including Dakin's and a saturated solution of sulfanilamide, although no particular importance was placed upon the use of any one solution. Emphasis was placed upon keeping the cavity clear and not allowing purulent exudate to accumulate. We endeavored in this way to prevent, as far as possible, the absorption of toxic products from the infected focus. It was felt that if any hope existed for the recovery of this patient, that this, at least, should be done. Cultures taken frequently from the cavity showed the usual mixed type of infection common to an open chronic cavity of this kind. All smears for tubercle bacilli were negative.

We were more or less skeptical of the apparent clinical improvement that occurred during this phase. It was felt that this might merely be a short respite and that at any time a remission might take place. The most important fact to record at this time was that the liver, by the spring of 1939, had become gradually smaller, and now was at the level of the umbilicus; no further regression could be noted over a period of from seven to eight months. The urine, although always boiling solid with albumin, had a slightly higher specific gravity.

During the latter months of 1939, consideration was first given to the idea of attempting to obliterate the chronic empyema cavity. For nearly a year there had been practically no change in the patient's condition. He had been up and about on limited activity. His temperature was normal. The chest cavity, which was irrigated carefully every day with the tube left in place, had shown no signs of becoming smaller although

a negative pressure had been maintained several hours each day. The urine continued to show 4 plus albumin and the liver edge had remained at the level of the umbilicus with no tendency to regress.

The reason for considering operation was the belief that no further improvement would continue since over this long period no change had been noted. There also was the fear that delay might result in the disease becoming active and pursue its characteristically fatal course. It was also felt that if the cavity could be completely obliterated the progress that had been noted might continue and that some hope of cure might be hoped for. Some consideration, too, was given to the patient's point of view. He had been extremely cooperative throughout his illness and now was anxious to subject himself to any therapy that offered some chance of cure regardless of the hazard involved.

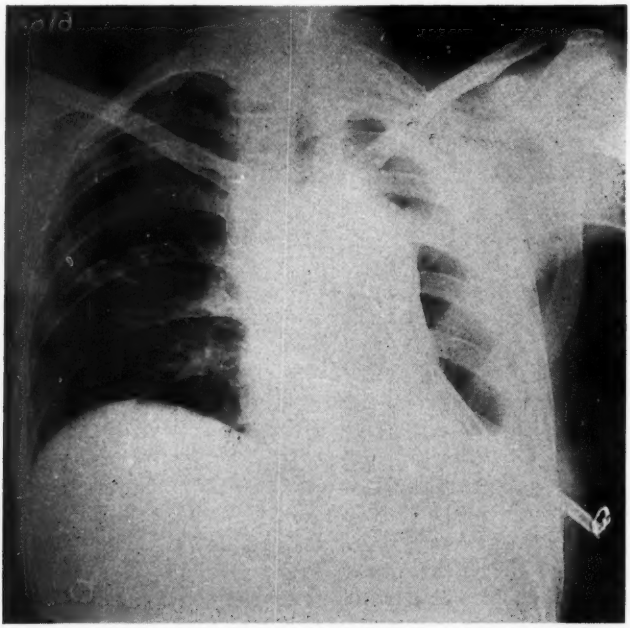

Fig. 2.—X-ray of chest (taken May 13, 1938) after drainage with intercostal catheter. Constant lavage was carried out during this entire phase.

The decision to operate was not undertaken lightly. It was realized, leaving the question of amyloidosis out of the picture entirely, that even the attempt at cavity closure might result in failure.

The troublesome questions that arose in considering surgery were: First, how well would this person tolerate a series of major operations with severe liver and kidney damage and evidence of generalized amyloidosis? I had never before had experience in dealing surgically with a problem of this kind and was unable to obtain helpful advice from

any source. Second, would operative interference with its added strain tend to stimulate a recurrence of amyloidosis in its more acute phase? Third, it was realized that unless the chronic empyema cavity was completely obliterated the operative attempt must be considered unsuccessful. The thickness of the pleura after six years of chronic infection had assumed enormous proportions and it was at once evident that complete rib removal alone without excisions of the pleura would probably not accomplish complete obliteration of the cavity. On the other hand, we were reluctant to undertake a Schede type of operation since the entire area was involved from apex to diaphragm and it would be an extensive and shocking procedure in a case where the surgical risk was doubtful at best. Finally, all biopsies taken from the sinus tract were positive for tuberculosis, and although this was not a direct contraindication to this type of operation we would have been less worried had we been dealing either with a shallow type of cavity or one that was not tuberculous. It was finally decided to do a complete extrapleural thoracoplasty, to remove the entire bony framework on the left side and at the same time formalize the periosteal rib beds to prevent regeneration. This latter procedure was done for two reasons: first, to allow a permanent period of contraction; second, in the event of failure, a Schede type of operation could be undertaken more expeditiously if it were not necessary to remove regenerated ribs in case a later operation became necessary.

The patient was admitted to the Rhode Island Hospital Jan. 4, 1940, for operation. Thoracoplasties were carried out on Jan. 5, Jan. 23, Feb. 14, and March 18. The entire bony framework from and including the first to the eleventh ribs and their transverse processes were removed, all anterior stubs being disarticulated at their cartilages through an anterolateral incision. The patient withstood all operations surprisingly well, in fact almost as well as the average good-risk thoracoplasty patient. They were carried out under intratracheal cyclopropane anesthesia and transfusions were given routinely. The patient recovered quickly from each stage and all postoperative convalescences were without event. Pressure sponges were applied to the chest and fixed with ace bandages. We were pleased to note that in spite of the great thickness of the pleura, marked collapse of the chest wall took place and the cavity became much smaller with each succeeding stage. When the patient left the hospital on April 9, 1940, it is recorded that the cavity held one and one-fourth ounces by actual measurement and it was hoped that nature would take care of this within a short time. Subsequent evidence indicated that this measurement was not correct. A small tube was left in the old sinus to take care of drainage until the remaining space should become obliterated.

After the completion of this series of operations the patient stated that he felt better than he had for some years. This was chiefly noted in his improvement in appetite and absence of nausea and indigestion

which had always been troublesome. He also gained ten pounds in weight. During this admission, as before, the patient was maintained on a high caloric, high vitamin, and high protein diet. His urine still contained 4 plus albumin and the specific gravity was generally low, 1.005 to 1.015. The blood urea nitrogen was always well below normal limits.

The patient was followed at home and in the office during the following months and his record was one of progress. He was up and about and outdoors, his appetite remained good, weight increased gradually, and the cavity appeared to be almost completely obliterated. On Aug. 23, 1940, it is recorded that it held only 15 c.c. However, there was one significant disturbing factor. Each time the tube was removed and the sinus allowed to close a low-grade fever invariably followed, yet lipiodol injection of the sinus failed to show any appreciable cavity. After removal of the tube had been attempted on several occasions it was decided that operative interference would be necessary, the extent of which could not be determined exactly until exploration of the sinus had been carried out. It was hoped that exteriorization of the sinus tract and allowing it to granulate would accomplish healing. With this in mind the patient was again admitted to the Rhode Island Hospital on Oct. 12, 1940, and on Oct. 15 exploration of the sinus was made. It was found to extend upward in the mid-axilla and was followed for a distance of about four inches. The parietal pleura was found to be firm and hard. At the uppermost point it was very narrow and at first it was believed that the entire sinus had been exposed, but it was discovered to run posteriorly at a sharp angle through a narrow opening. On exploring this with a curved clamp it appeared to open to a larger pocket posteriorly. The wound was packed with iodoform gauze and it was decided to explore the chest at a later date through a posterior incision. On Oct. 24, 1940, a paravertebral curved incision was made in order to explore this region. In cutting through the pleura a long cavity was exposed which was made up entirely of the paravertebral gutter, extending upward to the extreme apex of the chest and downward to about the level of the eighth rib. The small anterior communication which was seen at the previous operation was also observed. Resection of the pleura over this entire area was begun and carried out in such a manner that all shelving edges were removed. The technical difficulties that usually attend this type of operative procedure were encountered but were lessened by the absence of regenerated ribs. It was not possible to complete the unroofing in its entirety at a single stage. Following this operation the wound was closed and healed without evidence of infection. On Nov. 9, the incision was opened and the removal of the remaining pleura in this region completed. The soft tissues could now be molded into the cavity but it was necessary to remove the lower one-half of the scapula in order to accomplish this more effectively. These three operations were attended with a moderate degree of shock, but on

the whole recovery was without incident. Routine transfusions and oxygen were employed with each stage and the rapid postoperative recovery was rather surprising to us when we recalled the hesitancy with which surgery had been undertaken at the outset. Following all operations the patient was able to be out of bed on about the tenth day and subsequent progress was satisfactory. One cigarette drain was maintained for a few days at the lowermost point of the cavity but after

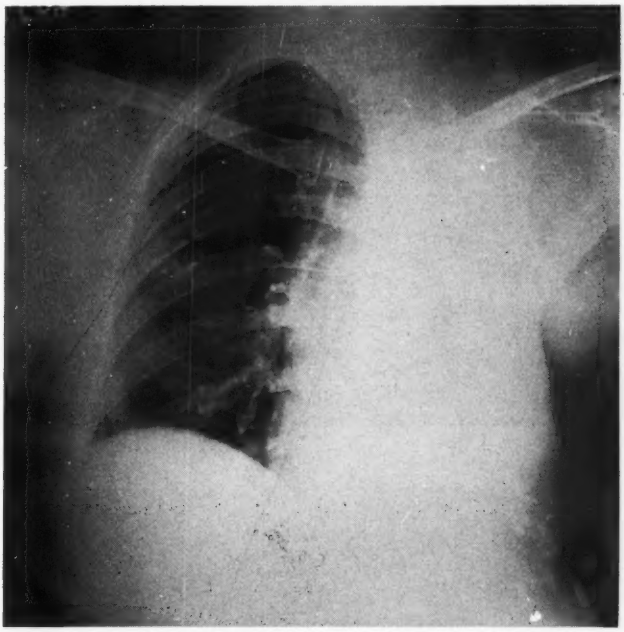

Fig. 3.—X-ray of chest (taken Oct. 13, 1942) after completion of both series of thoracoplasties.

demonstration that no dead space remained the sinus was allowed to heal. The thoracoplasty was so complete that the costal cartilages became the most prominent portion of the left thoracic cage and since they appeared to be creating a slight tenting effect, on Nov. 26, 1940, under local anesthesia, the second, third, and fourth costal cartilages were cut by multiple short vertical incisions at their sternal junctions and directed backward in line with the soft tissues of the chest wall. This appeared to be definitely worth while and allowed the pressure sponges to be applied with better effect.

The patient was discharged on Nov. 29, 1940. The posterior incision was healed and the anterior incision which had been originally packed open remained as a shallow granulating wound.

The following is the pathologic report on several sections made through the pleura:

"There are several sections all of which are essentially the same. The tissue consists of hyalinized fibrous tissue overlying muscle and fat. Overlying this are proliferating fibroblasts, many lymphocytes and areas of hemorrhagic necrosis. Several large tubercles are seen filled with

Fig. 4*A*.

Fig. 4*B*.

Fig. 4.—Recent photographs of patient (taken Dec., 1942).

epitheloid cells. There are also tubercles with caseous centers. Diagnosis: Tuberculosis of soft tissues of chest wall."

The progress of the patient since completion of all operations may be summarized as follows.

General Condition.—He began doing a limited amount of work at home in May, 1941. Even at this time he was feeling well and could probably have done much more but it was felt wise to keep him on restricted activity. In May, 1942, he was allowed to take a regular job as a laboratory technician on a half-time basis. After a few weeks this was increased to full time. He has been able to carry on this work without tiring and without loss of time.

There has been marked improvement in his general appearance. His appetite is good and he has been free from nausea or other gastrointestinal complaints. His weight gain has been from 116 pounds following his last operation to 156 pounds in May, 1942. He has maintained this weight until the time this paper was written, Dec. 20, 1942.

Wounds.—All wounds are healed. There was never any evidence of a residual cavity and no drainage tubes have been required since the completion of the operations. The anterolateral wound which was packed open healed slowly; this was partly due to the mechanical nature of the wound. However, the entire base was at all times visible and there was no evidence of sinus tracts communicating with it. Healing in this area occurred in Oct., 1941.

The Liver.—The position of the liver edge remained constant at the level of the umbilicus during the years 1939 and 1940. The last operation was completed Nov. 26, 1940. The liver edge was not palpable on Oct. 31, 1941.

Urine.—Urine examination has shown no appreciable change. The average specific gravity is 1.015. Albumin is at times 3 plus but usually 4 plus. The sediment shows occasional R.B.C.'s and W.B.C.'s and a rare granular cast. P.S.P. tests were made frequently during the illness but showed no significant change.

Nocturia usually occurs twice each night; this was present during the past three years of his illness and still persists.

Blood.—The blood cell picture remained within normal limits after the patient passed through the acute phase of the disease. During this period the R.B.C. count was slightly over 2,000,000 and hemoglobin as low as 45 per cent Sahli.

Blood chemistry checkup following operations was as follows:

Sugar	100 mg. per cent
N.P.N.	32 mg. per cent
Serum cholesterol	290 mg. per cent
Serum albumin	3.5 mg. per cent
Serum globulin	3.8 mg. per cent

Congo Red Test.—With the exception of one test taken on Oct. 17, 1939, which gave a reading of 16 per cent, all other tests up until May

11, 1942, showed from less than 5 per cent to 0 per cent retained in the blood after one hour, or from over 95 per cent to 100 per cent absorption of the dye. On May 11, 1942, 80 per cent was lost and on Aug. 10, 1942, 75.5 per cent. After four hours no dye has been recovered from the urine until the present time. Our experience with this test suggests that as a quantitative determination it is of little value after a certain point. For example, although clinical recovery had occurred and the liver edge had disappeared to palpation on Oct. 31, 1941, the Congo red test, on Nov. 4, 1941, showed more than 97 per cent of the dye lost. It is of interest to note that a test taken at the half-hour mark, on May 11, 1942, showed only 60 per cent of the dye lost and at the hour period 80 per cent. It is possible that the absorption rate may be a more reliable guide in determining the increase or decrease of amyloid material and could be determined by taking blood samples as often as every ten minutes for one hour.

CONCLUSION

Advanced amyloidosis is no contraindication to major surgery for the elimination of the focus of infection if the patient is otherwise a good surgical risk.

It is probable that in the case reported surgery might have been undertaken nearly one year earlier.

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PUTRID EMPYEMA

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WHILE a considerable amount of French and German literature has been developed on the subject of putrid empyema, thus showing a lively interest in this subject, very little is found in the English or American publications. It is interesting to note that Hippocrates was fully aware of this disease and in his aphorisms he says: "When at the opening of an empyema one finds white pus of a good nature the patients will recover, but on the contrary, they will succumb if the discharge is muddy and fetid."[1] This is probably the first recorded statement on the difference between ordinary pyogenic aerobic empyema and fetid or putrid anaerobic empyema, and on the clinical recognition of the difference between these two diseases from a prognostic point of view. It was Laënnec[2] who appeared to be the first to recognize the fact that the disease is most frequently secondary to rupture of a "gangrenous" pulmonary abscess into the pleural cavity. He explained the pneumothorax on the basis of chemical decomposition on the part of the albuminous substances. Veillon and Suber[3] and Guillemot, Halle, and Rest[4] were among the earliest investigators to show the etiologic relationship of the anaerobic bacteria to this disease. In 1934 Neuhof and Hirschfeld[5] published their report of fifty-one cases of putrid empyema. They divided their cases into three groups, basing this division upon the main clinical feature. The first group consisted of those cases in which empyema followed spontaneous rupture of an acute lung abscess, the second, those in which it followed spontaneous rupture of a chronic lung abscess, and the third those in which perforation occurred during operation. In these three groups they had a mortality of 8, 50, and 90 per cent, respectively. The causes of death in this series were as follows: empyema, twelve; extension of pulmonary infection, four; cerebral abscess, two; phlegmon of the chest wall, one. In another publication the same authors presented their findings on suppurative pleuritis in children in a series of seventeen cases in which there was a mortality of 29.4 per cent.

Maier and Grace[6] report a series of twenty-three cases with a mortality rate of 13 per cent. C. B. Wood[7] published the results in a series of eighteen cases treated at the Peter Bent Brigham Hospital in Boston. He had a mortality rate of 55.5 per cent. The causes of death in

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Received for publication March 24, 1943.

this series were: (1) extension of pulmonary disease in three cases; (2) altered pulmonary mechanics in three cases; (3) brain abscess in two cases; (4) pulmonary hemorrhage in one case; (5) thrombosis of the aorta in one case.

In view of the fact that putrid empyema has not received the recognition that it should as a definite and distinct disease different from the ordinary pyogenic post-pneumonic empyema, it has been deemed advisable to report briefly on the cases seen at the City Hospital.

The patients in a series of twenty-four cases, from 1924 to 1941, were treated by the different attending surgeons on duty. It is interesting to note how frequently the correct diagnosis was missed on admission (see Table III). In this group of cases the disease was found most

TABLE I

AGE OF PATIENTS

YEARS	NO.
1-10	3
11-20	2
21-30	2
31-40	4
41-50	3
51-60	7
61-70	3

TABLE II

CAUSES OF DEATH

CAUSE	NO.
Extension of pulmonary disease	2
Chronic empyema	1
Diffuse phlegmon of chest wall and empyema necessitatis	1
Undrained large empyema	1
Mediastinal flutter	1
Chronic sepsis, due to chronic abscess and bronchiectasis	1
Mucus plug at bifurcation of trachea with multiple pulmonary abscesses	1
Hemorrhage and chronic sepsis	1
Tension pneumothorax and chronic lung abscess	1
Brain abscess	1
Overwhelming sepsis and toxemia	1

TABLE III

ADMITTING DIAGNOSIS

DIAGNOSIS	NO.
Pneumonia	4
Pneumonia and pleurisy with effusion	3
Empyema	4
Lung abscess	3
Tuberculosis	3
Pleurisy	1
Pleurisy with acute cholecystitis	1
Cardiac enlargement with pulmonary congestion	1
Acute left heart failure	1
Chronic lung abscess	1
Acute sinusitis	1
Chronic bronchitis and bronchiectasis	1

frequently in the fifth age decade (see Table I). As far as sex is concerned, it appeared twenty times in males and four in females. The pathologic findings vary considerably. At the one extreme we find a small encapsulated empyema into which the acute lung abscess has perforated spontaneously and is draining satisfactorily. At the other extreme we find a total empyema with the lung filled with multiple abscesses either draining poorly or not at all, and the lung proper converted into a solid gangrenous, carnified, and airless mass. Treatment consisted of thorough, prompt drainage. It is interesting to note that in Neuhof's experience mediastinal shift is a rare observation. Still in Wood's fatal cases, three of the deaths were due to "altered pulmonary mechanics" and in a total of twelve deaths in the author's series, two patients died of similar complications. This matter is of vital importance in deciding whether to perform open or closed drainage in these cases. The decision is determined by the condition of the mediastinum. If this structure shows a considerable shift, thus showing abnormal mobility and lack of fixation, open operation should not be performed. In such cases, closed or underwater drainage is called for as a primary operative procedure to be followed later, when the mediastinum is fixed, by open drainage and rib resection. The following cases are reported briefly to illustrate this phase.

J. L. (No. 86535), 66 years of age, was admitted to the City Hospital, May 17, 1939. The patient was well until three months before admission, when he developed a productive cough that continued up to two weeks previously. At that time he suddenly stopped coughing and developed dyspnea, weakness, and loss of appetite. He was admitted with a diagnosis of cardiac enlargement and pulmonary congestion. Subsequent examination in the ward showed what was interpreted as unresolved pneumonia or malignancy. On June 2, 1939, the pleural cavity was aspirated and foul pus obtained. The patient was transferred to the surgical service on June 9 and was operated upon that day. Under local anesthesia, an intercostal incision was made between the seventh and eighth left ribs (D. H.). Foul, abundant pus was obtained and a rubber-tube drain was inserted into the pleural cavity and suction applied. The patient left the operating table in poor condition. A note made twelve hours later called attention to the fact that the patient was more dyspneic than before the operation. The patient died at 2 A.M. the following morning.

The other side of this picture is illustrated by the following.

G. S. (No. 110150), 56 years of age, was admitted to the City Hospital, Sept. 29, 1941. The patient fell into a stream of water seven weeks before admission and was treated symptomatically and returned to work in ten days. At that time he became quite ill and bedridden. He was treated for pneumonia by his family physician. It was then that he developed severe chest pains, dyspnea and foul expectoration.

This continued for about five weeks and he was then admitted to City Hospital. Physical examination revealed an elderly man who appeared moribund. The right side was greater in diameter than the left, all intercostal landmarks were obliterated, and there was no respiratory mobility nor breath sounds. The heart was shifted considerably to the left, underwater drainage was instituted immediately, and within the next twenty-four hours about one and one-half quarts of foul pus were evacuated. At this time the condition of the patient improved most dramatically and multiple rib resection and open drainage was done (I. K.). The right lung was collapsed, and solid and thick foul, gray exudate covered all pleural surfaces, visceral, parietal, and mediastinal. From this time on, a slow but progressive improvement took place and the patient was discharged on Jan. 18, 1942, with a small pleural cutaneous fistula which subsequently closed.

There are still some surgeons who advocate and practice repeated aspirations. The danger of this procedure is best exemplified by citing the following case.

I. F. (No. 73083), aged 57 years, was admitted to City Hospital on Oct. 14, 1937, for ruptured gastric ulcer for which he was operated upon that same day. Except for a mild infection of the abdominal wound, the postoperative course was uneventful till Oct. 29, 1937, when the temperature rose to 101.4° F. and the patient began to cough. The medical consultant diagnosed the condition as atelectasis and pneumonia of the right lower lobe. On Nov. 4, 1937, fluid was present in the right base, the temperature had risen to 102° F., and the patient complained of pain in the right shoulder. Four days later the right pleural cavity was aspirated and 50 c.c. of foul pus were obtained. The patient looked and felt quite sick. On the following day, Nov. 9, 1937, he was again aspirated and fourteen ounces of foul pus obtained. He was aspirated again the following day and thirty-two ounces of foul pus were removed. On Nov. 11, 1937, the attending surgeon (H. G.) advised repeated aspirations and thirty-five ounces of fetid pus were removed. This procedure was repeated on Nov. 12, 1937, with the removal of twenty-three ounces of foul pus. Again on the following day, Nov. 13, 1937, another six ounces were aspirated. Extremely sick, he was now transferred to the surgical service and operated upon (J. K.). There was found, in addition to a large empyema cavity, an extensive empyema necessitatis with pus burrowing through the muscles and throughout the subcutaneous tissue. The patient died that same day.

It is also worth mentioning in this discussion of the fatal cases, the importance of refraining from breaking down the adhesions to the wall of the empyema cavity from the remaining uninvolved pleural space. The following case exemplifies this point.

A. G. (No. 83476) was admitted to City Hospital on Feb. 10, 1939. He was operated upon Feb. 19, 1939, and a putrid empyema was found. Segments of the eighth and ninth ribs were excised. The empyema cavity was entered and sixteen ounces of foul pus removed. The floor of the empyema cavity was formed by eroded and ragged lung tissue. The adherent lung *was bluntly separated from the chest wall.* The separated lung tissue was found to be gangrenous. The wound was then packed and drained. This patient had a very stormy postoperative course and his condition became rapidly worse. On March 3, 1939, he died. At the post-mortem examination, the drained area appeared quite clean but the lung was found adherent to the upper angle of the wound (this was the area that had been bluntly separated at the time of operation), and when separated disclosed a large pocket of thick foul pus. The upper and middle lobes were compressed and collapsed.

DISCUSSION

Since practically all cases of putrid empyema are secondary to ruptured putrid lung abscess, it is obvious that the best treatment for this extremely serious complication is its prevention, and that, in turn, predicates early recognition and early treatment of the lung abscess before it has had time to perforate into the pleural cavity. Wessler and Neuhof and their associates have demonstrated conclusively that the diagnosis of a putrid lung abscess is, comparatively speaking, not difficult and in a large series of cases have showed that surgical treatment in the early acute stage is simple, safe, and effective.

Knowledge of the pathologic changes that accompany putrid lung abscess is essential for the understanding of the nature of this disease and this in turn enables us to understand the mechanism of the complications and sequelae. Comparatively early in the course of the disease, fibrous tissue is formed and the abscess wall rapidly becomes converted into a rigid fibrous tissue pseudocapsule so that even after a pneumonotomy is performed, the patient still is left with an uncollapsed, chronic fibrous-walled abscess. A second serious pathologic complication is the development of bronchiectasis in the pulmonary tissue immediately surrounding the abscess. It is quite obvious that incision and drainage of such a chronic lung abscess will have no effect upon the bronchiectasis, and the dangers incident to this condition will persist in spite of incision and drainage. In other words, the danger of direct spread of necrotizing suppurating pneumonitis, massive hemorrhage, suppurative embolization such as brain abscess, and general sepsis, still can take place.

The prognosis depends entirely upon the degree of the underlying pulmonary lesion and upon the effectiveness with which it can be treated. Here again the value of early recognition and early treatment of the causative factors can be readily seen. Where the empyema occurs in a patient with a chronic lung abscess, and where the under-

lying pathologic findings to a great extent are of an irreversible nature, the drainage of the empyema will not of itself have any effect upon the diffuse fibrosis, suppurative bronchiectasis, or pneumonitis, and it is upon these three processes that the prognosis depends. An entirely different situation exists in those patients in whom the underlying pulmonary condition is that of an acute lung abscess. Here the pathologic changes are not of an irreversible nature and the proper drainage of the empyema will be all that is necessary, except in those very few instances where spontaneous drainage of the lung abscess into the pleural space may be insufficient; this calls for treatment of the abscess itself at the same time. The matter of treatment can best be summarized by saying that early recognition and treatment of acute putrid pulmonary abscess is the best possible prophylactic treatment of putrid empyema.

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Editorial Announcement

Previously it has been customary to end the volumes of THE JOURNAL OF THORACIC SURGERY with the August issue. A change has been made, however, by which the future volumes will conform to the calendar year, beginning with the February issue and ending with that of December. The present Volume 12 will, therefore, continue through the December number and the index has been omitted from this number to appear instead in that issue.

Editor.